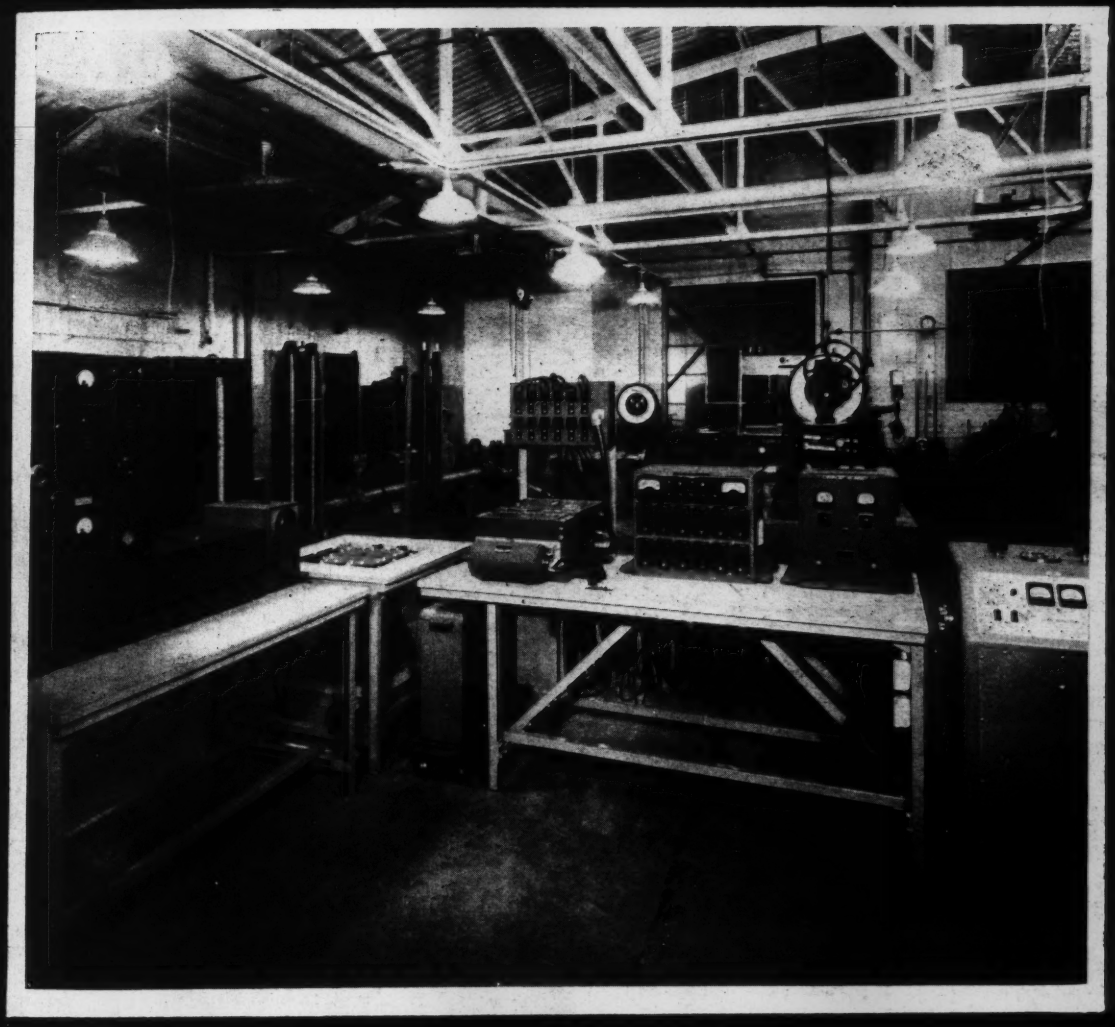
Instruments

THE MAGAZINE of MEASUREMENT and CONTROL

Vol. 24 | AUGUST 1951 | No. 8

INCLUDING THE *Journal of the Instrument Society of America*

AND THE *Journal of the Southern California Meter Association*



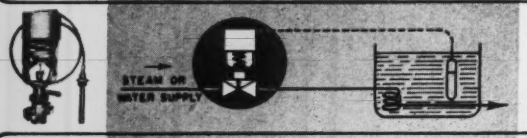
Instrumentation for testing components of valves and regulators. (Story on page 814)

(Photo courtesy Fisher Governor Co.)

Automatic CONTROL *...at its Simplest!*

TAG Non-Indicating Controllers *Regulate Temperature and Pressure*

SELF OPERATED TEMPERATURE OR PRESSURE CONTROLLER

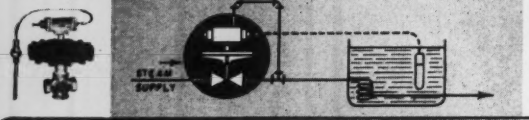


Controls temperature (as shown) or pressure.

•

Requires no air or electric power supply.

STEAM OPERATED TEMPERATURE OR PRESSURE CONTROLLER

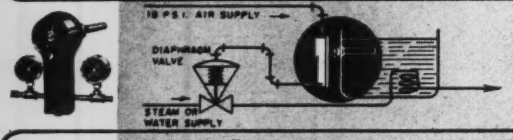


Controls steam pressure (as shown) or temperature (dotted line).

•

Operates on upstream steam supply. Needs no air or electric power.

"FAULTLESS" TEMPERATURE CONTROLLER

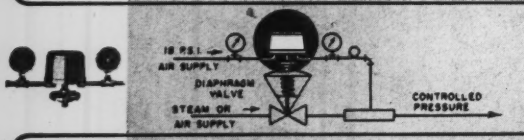


Controls temperature only.

•

Operates diaphragm valve on 18 p.s.i. air supply.

"SIMPLEX" PRESSURE CONTROLLER

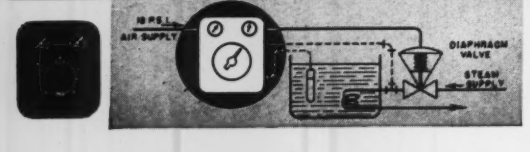


Controls pressure only.

•

Operates diaphragm valve on 18 p.s.i. air supply.

NO. 42 TEMPERATURE OR PRESSURE CONTROLLER



Controls temperature or pressure.

•

Operates diaphragm valve on 18 p.s.i. air supply.

Long life, trouble-free service and ease of maintenance are inherent characteristics of TAGliabue Non-Indicating Controllers. When your purpose is to devise a temperature or pressure control system at its simplest, these TAG controls will often prove the answer. Send now for your copy of Catalog No. 900, which gives you 36 pages of detailed data on these instruments and related equipment.

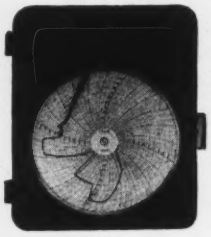
TAGLIABUE INSTRUMENTS DIVISION

WESTON ELECTRICAL INSTRUMENT CORPORATION

614 Frelinghuysen Avenue, Newark 5, New Jersey

TAGliabue Pressure Recorder Charts Up To 7,500 P.S.I.

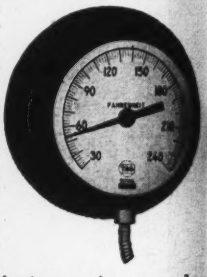
Catalog No. 1210 Recording Pressure Gages, available from TAGliabue Instruments Div., Dept. 67, Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J. combine simple design with accurate calibration. They provide permanent records of vacuum or pressure on either 10-inch or 12-inch circular charts.



Interchangeable tube systems of these TAG instruments are laboratory calibrated at the factory. Safety links provide over-range protection. These recorders are supplied in various ranges between the limits of 30 in. vacuum and 7,500 lb. per sq. in. pressure.

TAGliabue Dial Thermometers Provide Remote Indications

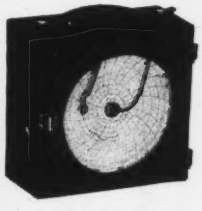
Temperatures are accurately shown at a distance from the sensing element with the Dial Indicating Thermometers produced by TAGliabue Instruments Div., Dept. 67, Weston Electrical Instrument Corp., Newark 5, N. J. These sturdy devices are furnished with mercury, gas filled or vapor tension actuations in 5, 6 and 8" dial sizes.



The plain black pointer and figures make TAG Dial Indicating Thermometers easy to read. The instruments are made in two types, for flush or wall mounting, with cases of iron, brass or phenolic plastic. Models are available to indicate as low as −325°F. or as high as 1000°F.

Temperatures in Mobile Units Charted by Miniature Recorder

A continuous record of temperatures in heated, refrigerated or air conditioned spaces is provided by a miniature self-contained recording thermometer developed by TAGliabue Instruments Div., Dept. 67, Weston Electrical Instrument Corp., Newark 5, N. J. This new instrument, known as the TAG Model 8475 Miniature Recorder, requires no connection to any power supply, yet charts temperatures for as long as seven days without attention.



Its unique design eliminates need for shockproof mounting. Temperatures as low as −30°F. or as high as +220°F. can be recorded. The instrument measures 5¾" x 5¾" x 4¼", and weighs 3½ pounds.

A Range of Ten Billion to One

with this CAPACITANCE TEST BRIDGE

THIS Type 1611-A Capacitance Test Bridge represents an important advance in instrumentation with its increased accuracy, improved sensitivity and extra convenience in operation over test bridges formerly available through General Radio Company.

This bridge measures capacitance from 0 to 11,000 μf with an accuracy of $\pm$ (1% + 1 $\mu\mu$f) over the entire range.

This bridge is very useful for laboratory or shop tests on all kinds of paper, mica and electrolytic condensers. It is very useful for measurements of dissipation factor on bushings and insulators and electrical insulation. For measurements of dissipation factor and dielectric constant of both solid and liquid dielectric materials in chemical and plastic laboratories it provides a highly accurate, sensitive and convenient-to-use instrument.

Capacitance and Dissipation-Factor Dials *direct-reading through a single window; dials approximately logarithmic*

Unique Zero-Compensating Circuit *requiring no "zero" corrections for accurate determinations of capacitance and dissipation factor, even at lowest bridge values*

High Sensitivity . . . *capacitances between 100 and 11,000 μf can be balanced to a precision of at least 0.1%*

Excellent Dissipation-Factor Accuracy *of $\pm$ (2% of dial reading plus 0.05% dissipation factor) over entire range of 0 to 60% at 60 cycles*

Improved Detection Circuit *with single-stage amplifier and electron-ray tube as visual null indicator . . . circuit designed to be very sensitive at or near balance and insensitive off balance*

Polarizing Voltage *can be used through external connections up to 500 volts, d.c. One terminal grounded so that a-c operated power supply with grounded output can be used*

Uniform Power Delivered to Bridge . . . *four separate sources of proper impedance and voltage, each providing maximum safe power to bridge, automatically selected by multiplier ratio switch*

Type 1611-A
Capacitance Test Bridge
$440

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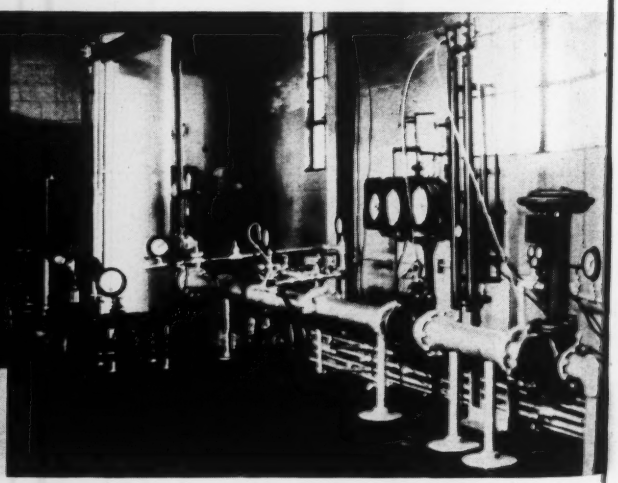
WHY MOST LEADING COMPANIES

It is logical that leading companies should handle the important subject of control valves as they do other matters: They make use of the best available skills and thinking. More and more, they utilize the equipment, knowledge and facilities of the K & M engineering and service team.

Five years ago, K & M Advanced-Type Control Valves were new to industry. Today, with outstanding performance records behind them, K & M valves have become first in the regard of many instrument engineers. Increasingly, K & M representatives are called upon to give counsel and assistance in the planning of new control installations and the improvement of old ones. During the past year K & M men have been consulted on most of the projects in which control valves have been a major consideration.

There is a qualified K & M representative near you, eager to discuss your problems and able to help you with them.

FACILITIES — K & M has facilities to handle the smallest or largest control valve requirement. This photo was taken during the manufacture of some 36-inch double-ported valves, the largest ever made.



NEW THINKING — K & M men have applied new thinking and new methods to control problems. Here is a corner of the K & M laboratory, where many important ideas have been successfully developed.

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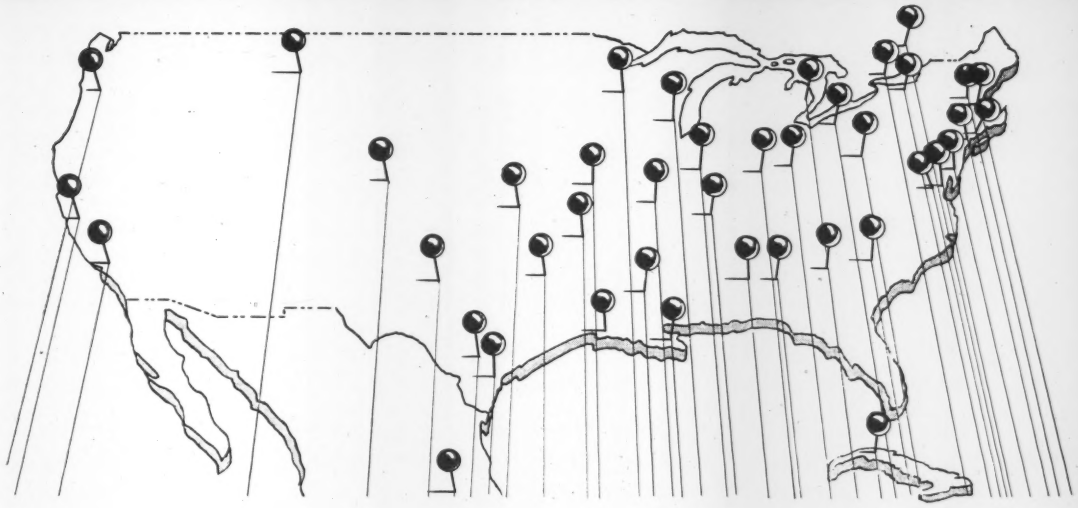

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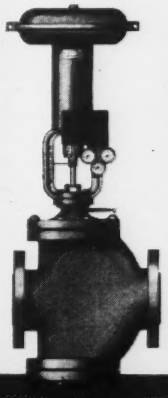

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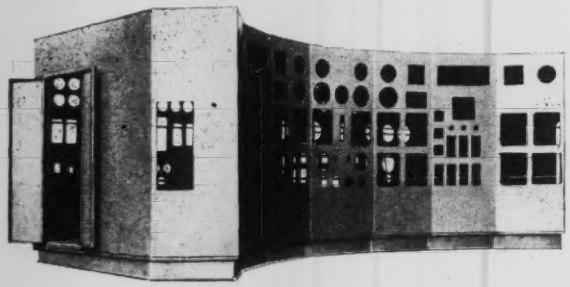

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Instruments
THE MAGAZINE OF Measurement and Control

Vol. 24 AUGUST 1951 No. 8

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Measurement of Flow of Fluids through Orifice Meters (Part II) 975
By William L. Cowan

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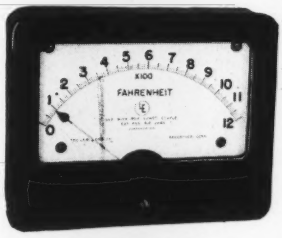
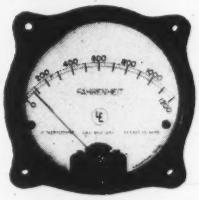
Sturdy Dependable Indicators —Suitable For Use In Moving Vehicles or For Permanent Installation

This instrument has been used extensively by the leading motor-car manufacturers for road testing on the "Proving Grounds" — where performance counts. Housed in a rectangular bakelite case, this reliable, fully compensated pyrometer is furnished with 6 in. hand drawn scales for greater accuracy. The Model 58PY is available for use with all standard thermocouple materials, in many ranges to suit the most exacting application.



MODEL 58PY

Manufactured with the same type of movement as our aircraft pyrometers, the Model 23B pyrometer is well suited for use in moving vehicles and has been successfully used in many marine diesel installations for measuring exhaust temperatures. It is housed in a 4 in. round bakelite case that is flanged for panel mounting, and is available in several ranges for use with various thermocouple materials.



MODEL 23B.

The Model 20B series of indicators are patterned after our standard aircraft instruments and are supplied with 3" round steel cases suitable for panel installation. These compact, sturdy indicators have 2⅛ in. scales, are fully cold-end compensated and are available in many ranges for use with various thermocouple materials.

MODEL 20B

The Model 62RT4F resistance thermometer is a sturdy easy-to-read instrument with a 6 in. hand drawn scale. It is suitable for use in moving vehicles and is excellent for flight-test work. It is operated by an ordinary dry cell and is calibrated to standard "AN" bulb curves for various ranges in fahrenheit or centigrade.

MODEL 62RT4

THERMOCOUPLES for use with the above indicators are available in many styles for special applications. We have developed a complete line of aircraft, industrial and automotive thermocouples and would be pleased to offer our recommendation for your application.

THERMOCOUPLE LEAD WIRE for connecting thermocouples to the indicators is manufactured in iron-constantan, copper-constantan or chromel-alumel material with standard and special insulation. Use Lewis lead-wire with Lewis instruments and thermocouples for best results.

RESISTANCE BULBS for use as sensing elements for the 62RT4 thermometers are available in several types for various applications, for measuring free air or liquid temperatures. We invite inquiries on your application.

THE LEWIS ENGINEERING CO.

Specialists in Electrical Temperature Measurements

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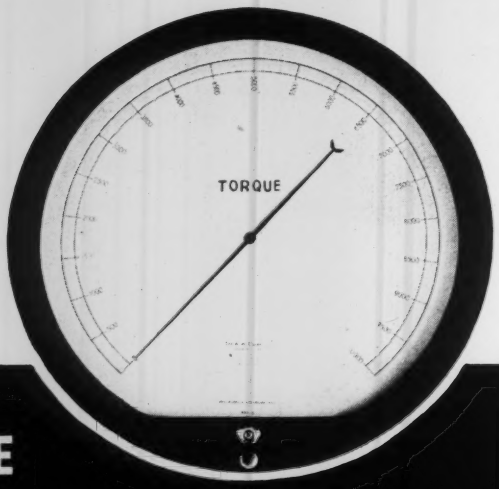

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COVER PICTURE

Specialized equipment in Research Laboratory of Fisher Governor Co., Marshalltown, Iowa, tests valves and regulators. At left is 2-cps. to 70,000-cps. vibration test equipment for checking natural frequencies of valve parts, and for fatigue testing. It was made by the M-B Mfg. Co., New Haven, Conn. On center table is 12-channel recording oscillograph connected to pickups such as Baldwin Southwark SR-4 strain gages. It was made by the Hathaway Instrument Co. of Denver, Col. At the right is a mass-spectrometer leak detector made by Consolidated Engineering Co. of Pasadena, Calif.

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MAINTENANCE MAN ATTACHES CLIPS OF TESTING INSTRUMENT TO CALIBRATION TERMINALS

New G-E Pyrometer Equipment Quick and Easy to Inspect and Maintain

Routine inspections of the new General Electric Type HP pyrometers can be made in the most time-saving ways—as these illustrations show.

Besides making preventative maintenance easy, this equipment has many other features to provide accurate indication and temperature control of furnaces, ovens, kilns, and other industrial-heating equipment.

ACCURATE INDICATION. Calibrated accuracy is within ¾ of 1 per cent of full scale. Automatic cold-junction compensation adjusts for changes in ambient.

CLOSE TEMPERATURE CONTROL. Any change in temperature, even as small as 0.1% full scale, starts immediate control action. Normal changes in humidity, ambient, and voltage have little or no effect on the exactness of control action.

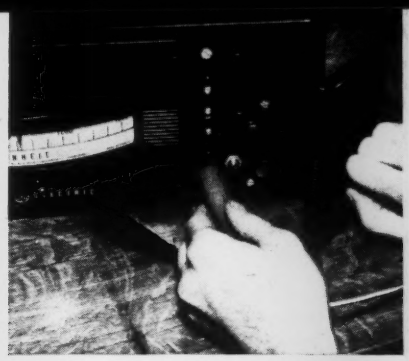
DEPENDABLE OPERATION. Strong construction throughout makes G-E pyrometer equipment exceptionally rugged. A 3¼ pound alnico magnet provides high flux density and allows large air gaps. Lightweight moving system effectively resists shocks and vibration.

FOUR TYPES AVAILABLE indicating, protecting, two- and three-position control forms. Both flush and surface mountings can be supplied. All models are available in a variety of temperature ranges in the 0–3000 F span.

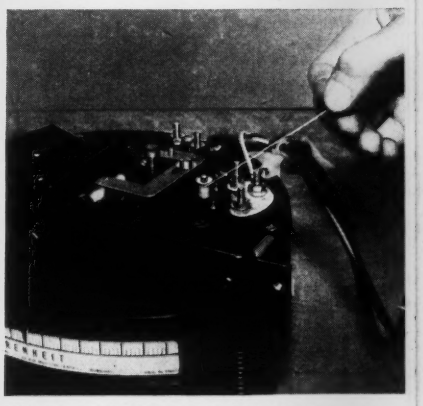
For more information, call your G-E representative or write for Bulletin GEC-713. General Electric also offers a complete line of thermocouples—described in GEC-714. Write Section 602-208, General Electric Company, Schenectady, New York.

GENERAL ELECTRIC

602-208

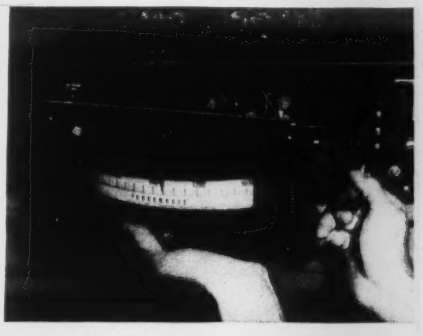


CALIBRATION CHECKS are made quickly and without disassembling pyrometer. First, remove right-hand panel. Then attach the clips to the terminals—as shown on left.



LEAD-LENGTH RESISTANCE can be changed conveniently when pyrometer is switched to another job. Simply adjust the lead-length spool mounted on top of indicator.

PLUG-IN CONTROLLER permits easy replacement if failure occurs. Both the controller and the protector units have plugs directly attached. Just slide the unit in place.



INDICATOR EASILY CHECKED or very quickly replaced if the need arises. The unit is connected to the terminal board by means of a plug on a short length of cord.

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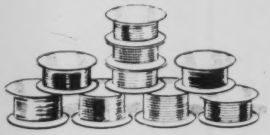
PYROMETER & SUPPLY CO.

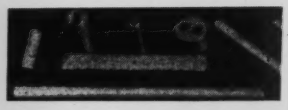
SAM HOUSTON COLISEUM

WIRES

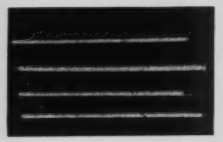


THERMOCOUPLE HEADS

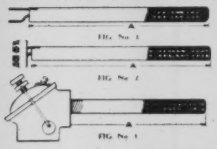
INSULATORS



TUBES



THERMOCOUPLES



THERMOCOUPLE LEAD WIRES

AT HOUSTON . . . as at Buffalo, INDUSTRIAL PYROMETER is planning an exhibit of equipment which will be **informing** and helpful. Be sure to drop in. Remember, our plant and manufacturing facilities are geared to the defense program and needed domestic requirements.

Industrial . . .

Manufacturer of 58 Types of Insulated Thermocouple Lead and Special Wiring!

MEN of PYROMETRY

Visit Our Booths Nos. 238 & 240

And Receive an Invitation

To An Enjoyable Evening

IF YOU CANNOT ATTEND THE EXHIBIT SEND FOR OUR LATEST CATALOG

INDUSTRIAL PYROMETER & SUPPLY CO.

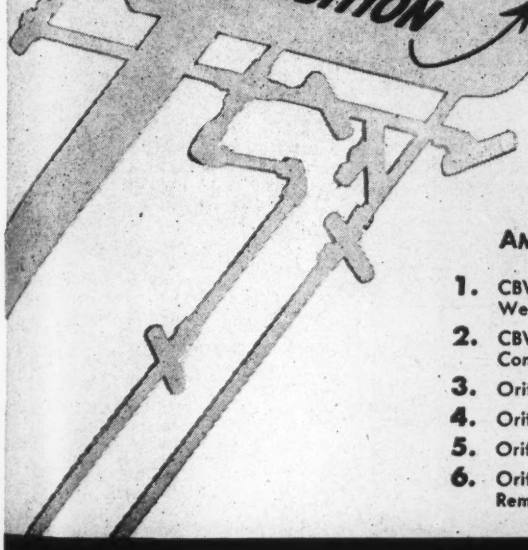
A. L. HACK, *President*

ALTON, ILLINOIS, U. S. A.

Coming!

A New Development of Great Interest to Instrument Engineers.

SEE IT AT THE INSTRUMENT SOCIETY OF AMERICA EXHIBITION



SAM HOUSTON COLISEUM
Houston, Texas

September
10-14, 1951
Booth 101-5

AMERICAN METER COMPANY PRECISION EQUIPMENT

1. CBV Regulators, Pilot, Spring or Weight Loaded
2. CBV Regulators, Pilot Remote Controlled
3. Orifice Meters, Recording
4. Orifice Meters, Integrating
5. Orifice Meters, Telemetering
6. Orifice Meters, Integrating, Remote Counter
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9. Differential Valves
10. Controllers, Pressure
11. Controllers, Flow
12. Temperature and Pressure Recorders

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Canadian Meter Co., Ltd., Hamilton, Ontario

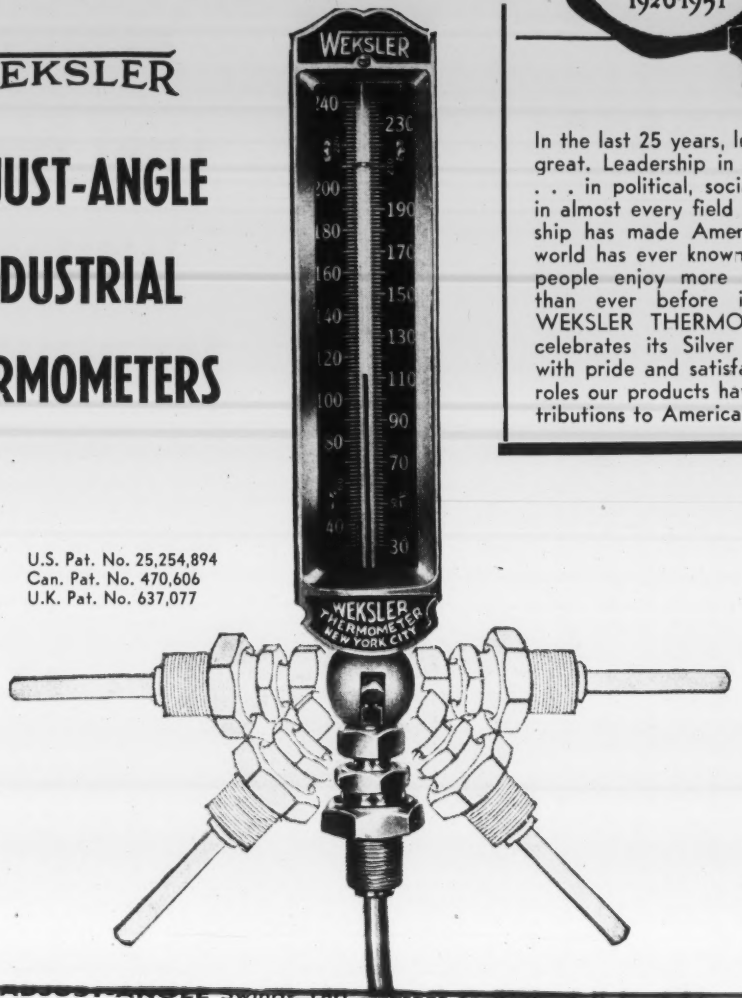
AMERICAN METER COMPANY

MARCH OF PROGRESS

OUR 25TH Anniversary 1926-1951

WEKSLER N.Y.C.

WEKSLER ADJUST-ANGLE INDUSTRIAL THERMOMETERS



U.S. Pat. No. 25,254,894
Can. Pat. No. 470,606
U.K. Pat. No. 637,077

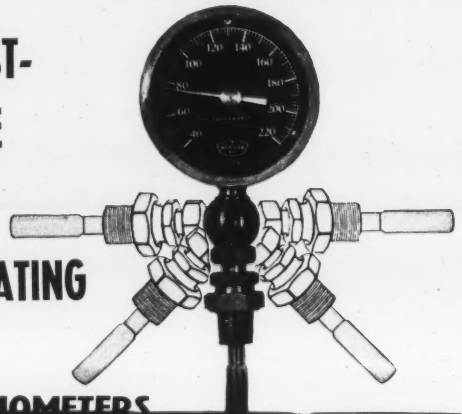
In the last 25 years, leadership has made America great. Leadership in commerce, finance, industry . . . in political, social and military matters . . . in almost every field of human effort . . . leadership has made America the greatest nation the world has ever known . . . a country where more people enjoy more of the good things in life than ever before in history. Today, as the WEKSLER THERMOMETER CORPORATION celebrates its Silver Anniversary, we look back with pride and satisfaction on the many different roles our products have played . . . countless contributions to America's growth and progress.

Wherever there has been a need to measure and record temperature, pressure, or humidity . . . be it in the laboratory, manufacturing process or household . . . on or under the seas, on land or in the sky . . . there you will find WEKSLER INSTRUMENTS. WEKSLER leadership has been built on three cardinal principles: to produce instruments of highest quality and undeviating accuracy . . . to create new instruments to serve new needs . . . to cooperate in all ways and at all times with all customers! These same principles will continue to guide and inspire WEKSLER'S march of progress in the years ahead.

ADJUST-ANGLE Swings 180° front to back—left to right.

ADJUST-ANGLE simplifies maintenance—reduces stock re-

ADJUST-ANGLE DIAL-INDICATING THERMOMETERS



Here, too, is an instrument of many uses—with the same convenience as the industrial thermometer shown

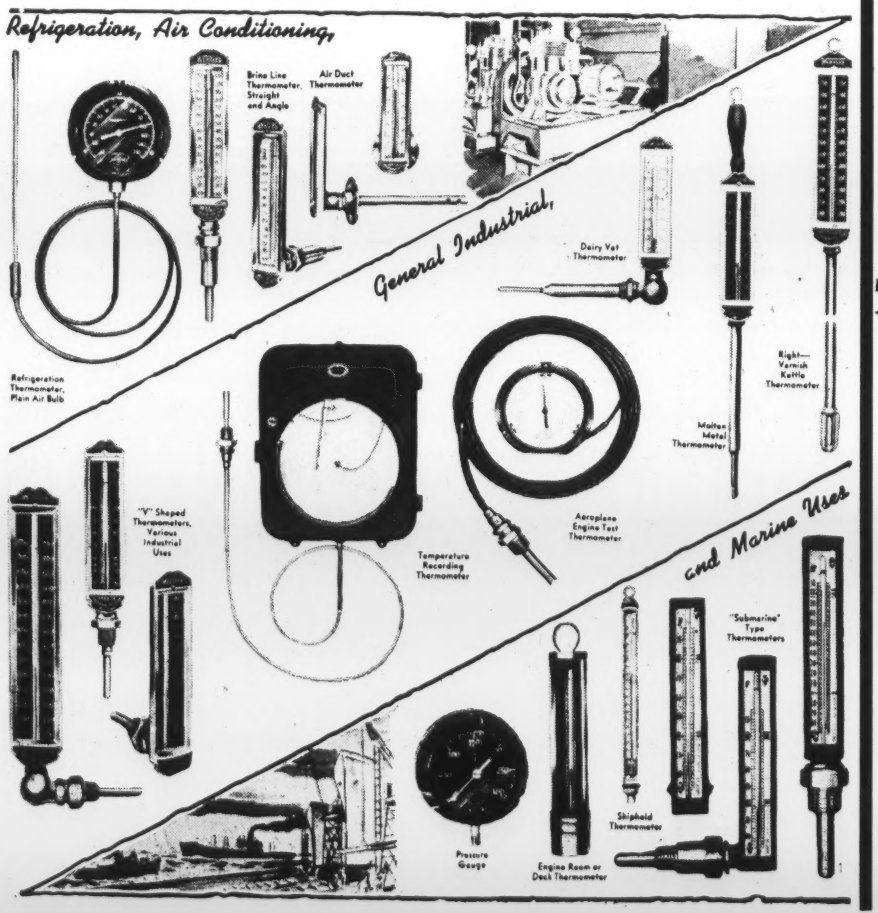
ADJUST-ANGLE Swings 180°—front to back—left to right.

ADJUST-ANGLE simplifies maintenance—reduces stock requirements.

ADJUST-ANGLE is visible at any angle—simple installation.

ADJUST-ANGLE minimizes breakage—easily adjusted.

ADJUST-ANGLE is supplied with INTERCHANGEABLE Union or Separable socket. 7, 9 or 12-inch cases —3½" to 30" stem.



THERMOMETERS

Here, too, is an instrument of many uses—with the same convenience as the industrial thermometer shown at right. Available in Phenol, Aluminum or Brass Case in 4½", 6" or 8" dial. Union or separable socket connections.

LABORATORY INSTRUMENTS, HYDROMETERS, HYGROMETERS AND PSYCHROMETERS

Weksler instruments are used by Government departments, Weather Bureaus, Testing Laboratories and leading schools and universities all over the world. All made with the accuracy vital to the successful completion of tests, experiments and checking of manufacturing processes. Fahrenheit, Centigrade or specialized scales as required.

WEKSLER *VERSATILITY*

"If it's a thermometer, we'll make it . . ."

The tremendous variety of instruments, calibration scales and controls which we make to individual requirements, carries out one of the important policy points of this Company. If yours is a difficult problem in instrumentation, bring it to the attention of our technical staff.

YOU CAN MAKE GOOD USE OF THESE WEKSLER CATALOGS

No. 125 Industrial Thermometers
No. 225 Engraved-on-Stem Glass Thermometers and Hydrometers
No. 325 Dial-Indicating and Recording Thermometers
No. 525 Dial-Indicating and Recording Pressure Gauges

WEKSLER

THERMOMETER CORP.

52-56 West Houston Street, New York 12, N. Y.

Representatives in principle cities throughout the United States and foreign countries.

Engineering Data

on ARNOLD TAPE-WOUND CORES

PROPERTIES OF . . .

DELTAMAX
4-79 MO-PERMALLOY
SUPERMALLOY*

*Manufactured Under License Arrangements with Western Electric Co.

BULLETIN TC-101
August 15, 1951

THE ARNOLD ENGINEERING COMPANY

SUBSIDIARY OF ALLEGHENY LUDLUM STEEL CORPORATION

General Office & Plant: Marengo, Illinois

WRITE FOR YOUR COPY

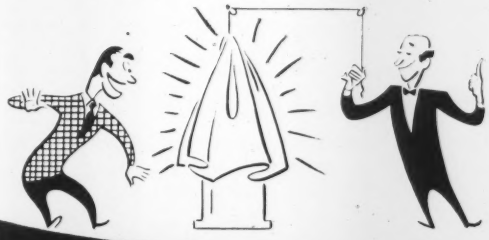
W&D 3611

Have you been reading lately about unbalanced forces in **CONTROL VALVES**?

Have you seen how ordinary **CONTROL VALVES** *bounce around when differential pressures change*?

Have you wanted to throw out obsolete, inaccurate **CONTROL VALVES**?

Then you should see the unveiling of the



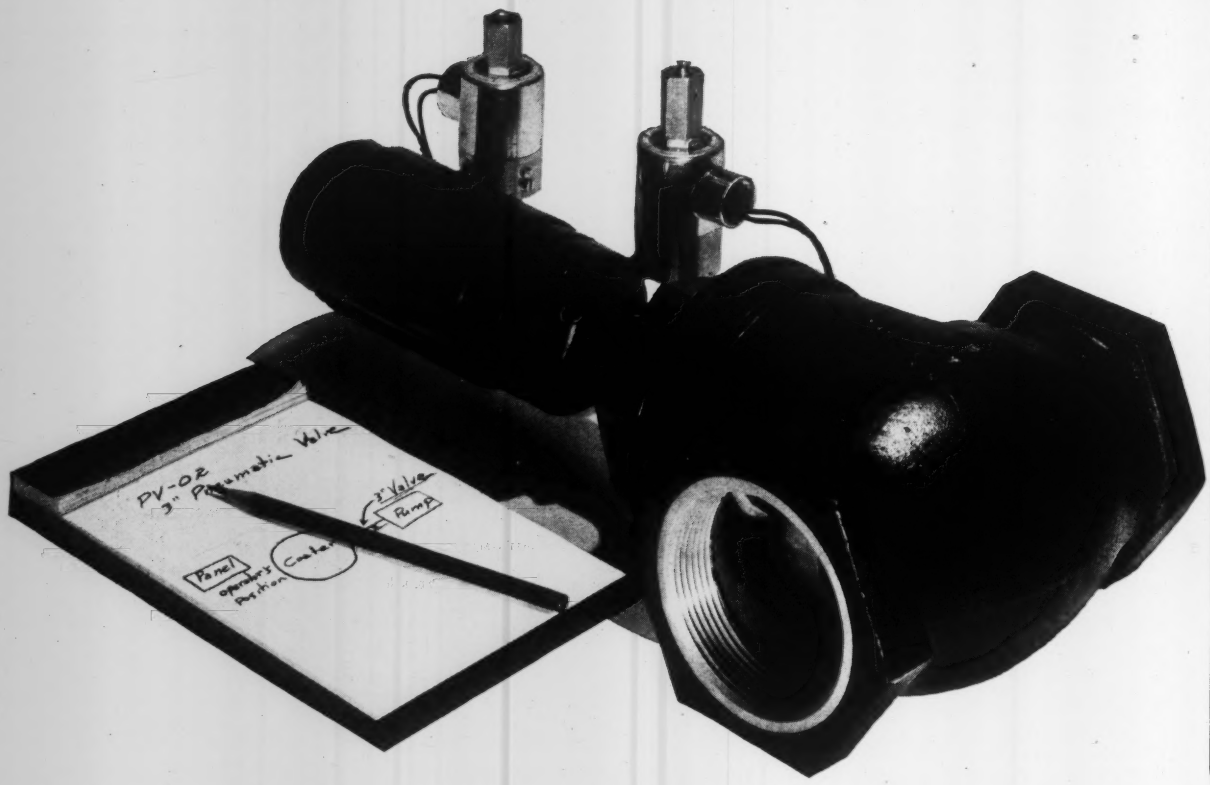
ANNIN SHUTTLERATOR

at the **INSTRUMENT SHOW IN HOUSTON ON SEPT. 10-15, 1951.**

★ *No erratic unbalanced force*
★ *Accurate under all pressure differentials*
★ *1000 to 1 control rangeability*

THE ANNIN COMPANY

3500 UNION PACIFIC AVE., LOS ANGELES 23, CALIF.



Compressed Air Controls High Vacuum

...AND DPi HAS 10 SIZES OF VALVES TO DO IT

DPi NOW OFFERS pneumatically operated valves in the smaller sizes, as well as the larger sizes previously available.

This means that now, with DPi's complete line of valves ranging in size from 3″ to 32″, you're assured of instant, sure-seal control, for any size high vacuum system.

In the new smaller-sized pneumatic valves, compressed air at 50 p.s.i. provides a positive seal that can be put into action instantly by electric controls, and will hold indefinitely. The small combined size of valve and operator means easy installation where space is at a premium. You get convenient, automatic operation for your high vacuum system . . . enjoy the advantages of both compressed air and remote electric control.

These new valves are another step in DPi's continuing program to make industrial applications of high vacuum as convenient and automatic as possible. As specialists in the design and building of high vacuum installations—whether it be a special valve or a complete system—DPi invites your inquiries. Write to *Distillation Products Industries*, Vacuum Equipment Department, 65 Ridge Road West, Rochester 3, N. Y. (Division of Eastman Kodak Company)

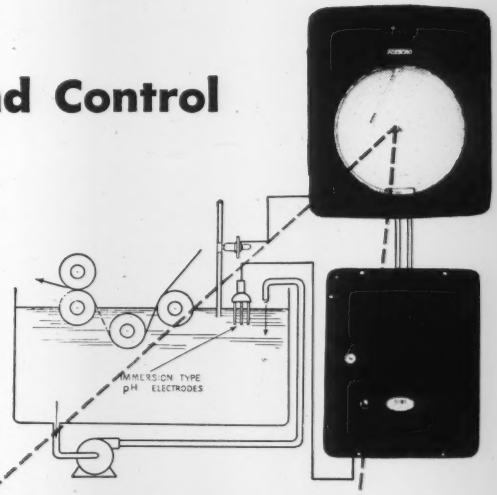
high vacuum research and engineering

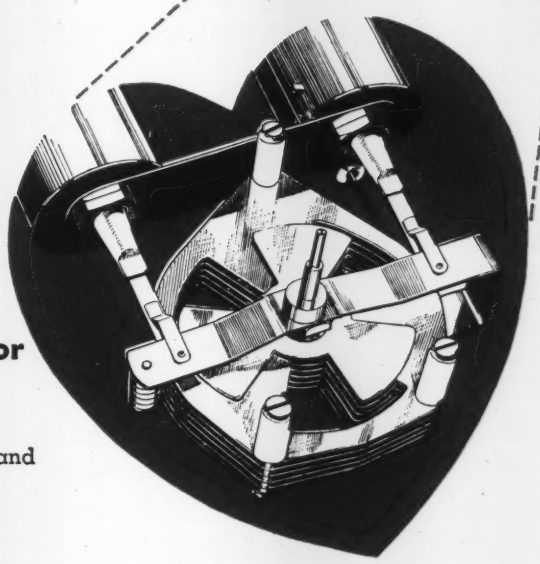
DPi

Also . . . vitamins A and E . . . distilled monoglycerides . . . more than 3400 Eastman Organic Chemicals for science and industry.

Accurate pH Measurement and Control

IT'S "DUCK SOUP" FOR DYNALOGS*





In many chemical operations, accurate control of pH is essential to maximum yield and purity of product since it governs reaction velocities and suppresses undesirable side reactions in the processing.

Here's why Dynalogs are ideal for Measuring or Controlling pH

The heart of Dynalog Instruments, shown at the right, eliminates the conventional slidewire and provides an unequalled combination of speed, sensitivity and accuracy. This *stepless* as well as continuous balancing mechanism responds quickly and positively to the smallest change in pH values.

Whatever your requirements for accurate pH measurement or control, there's a Foxboro Dynalog Instrument designed to meet them . . . indicating, recording or controlling. Write for Bulletin 468. **The Foxboro Company, 40 Neponset Ave., Foxboro, Mass., U. S. A.**

* Reg. U. S. Pat. Off.

ADVANCED ENGINEERING THROUGHOUT

Designed to take full advantage of electronic circuits, Dynalog Instruments are virtually free from the mechanisms used in conventional bridge-type instruments. They have no slidewire, no moving contacts, no high-speed motor, no gears, no galvanometer, no batteries to standardize. They require essentially no maintenance except occasional replacement of standard radio tubes. Pneumatic Dynalog Controllers are available where automatic operation is desired.

Beckman Glass Electrodes are the primary elements of Dynalog pH Instruments. They are suitable for use in nearly all types of solutions regardless of color, viscosity, rate of flow, suspended solids and oxidizing or reducing agents.

FOXBORO
Reg. U.S. Pat. Off.

DYNALOG ELECTRONIC INSTRUMENTS

Presenting the new

REPUBLIC Electronic M

FEATURES

NO DEAD SPOTS OR LAGS

The TELEMASTER operates on a null-balance principle with a constant check-back between the initial input and final output, with no intervening mechanisms to cause dead spots or lags. This balance type detection of any deviation in the desired operating conditions, produces a highly responsive and fast acting control system.

ELIMINATES PANEL PIPING

No control panel piping is necessary with the REPUBLIC TELEMASTER. Easily installed, multi-wire cables are the only connection between the TELEMASTER benchboard and the plant measuring and control elements. Results? Easier, faster and better appearing installation, increased flexibility, economy, and reduced maintenance.

GREATER APPLICATION FLEXIBILITY

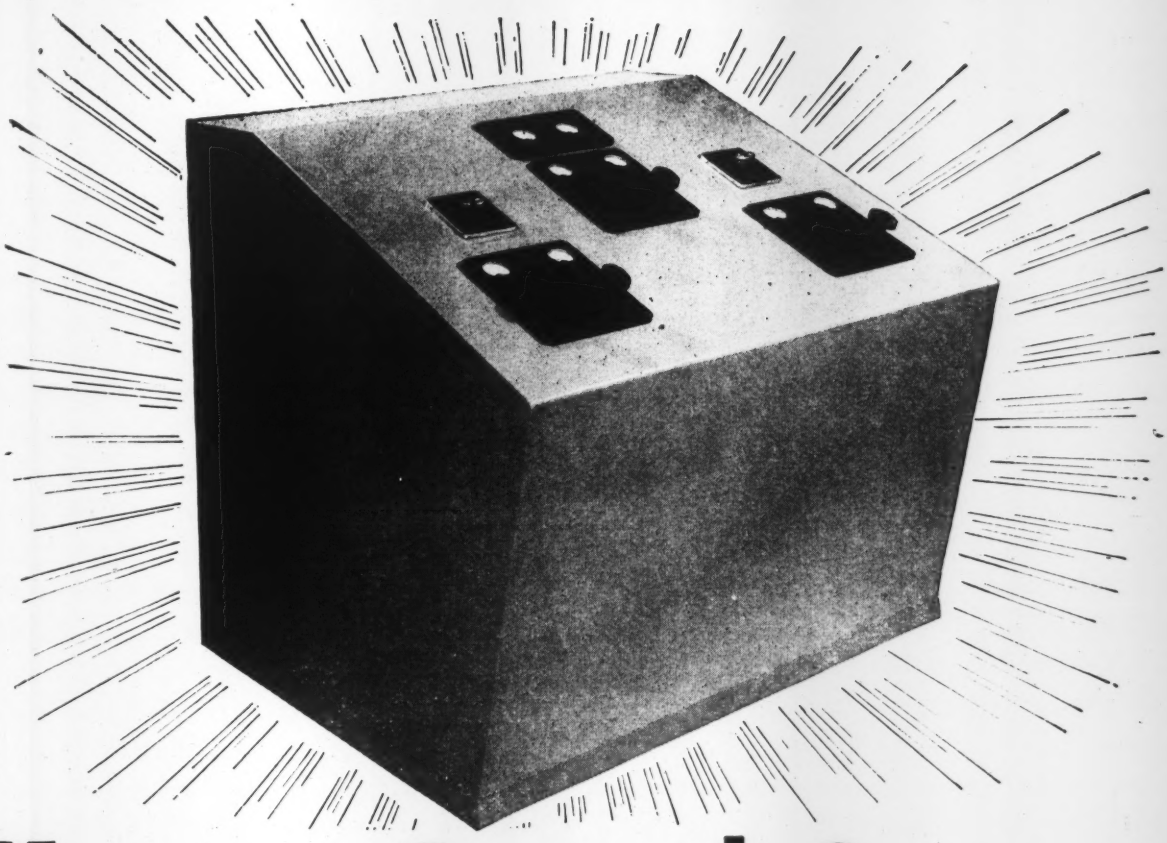
Flexibility required for complete centralization of controls at a central focal point is a distinct feature of the TELEMASTER. The system may be operated under completely automatic, semi-automatic, or manual control from a central supervisory station.

PLUG-IN INTERCHANGEABLE PARTS

Due to simplicity, compactness and interchangeable component parts the TELEMASTER provides a more flexible control system and a more condensed panel area than previously possible. All parts subject to replacement are mounted on compact plug-in units that are easily interchanged and replaced with spare parts.

REDUCED MAINTENANCE

Control room maintenance is sharply reduced. No moving parts or mechanisms are mounted on the control panels. Panel equipment is smaller and less cumbersome, no panel piping is used. Plug-in replacement parts may be installed in a matter of seconds. All components of the TELEMASTER are fully tested and proven for prolonged trouble free service.



Master Control System

"TELEMASTER"

The new Republic Electronic TELEMASTER Control represents a major advance in the field of automatic control. The TELEMASTER will remotely reproduce, instantly and accurately, a position or a force — perform arithmetical and algebraic calculations—and can be used for multiple operations. Essentially it performs the function of a mechanical link through electrical and electronic means. It is applicable to all types of combustion and process control.

In plants where distances between operating units are great, the lags inherent in the compression effect of a pneumatic master system are appreciable. This effect is frequently sufficient to prevent realization of the full benefits of automatic control. The Republic Electronic TELEMASTER Control has no inherent lag, regardless of distance. This means that centralization of operations can be achieved without any sacrifice of control performance. *Full details sent upon request.*

E IT OPERATE. VISIT BOOTH NOS. 430-436, NATIONAL INSTRUMENT EXHIBIT, HOUSTON

REPUBLIC FLOW METERS CO. ● 2240 DIVERSEY PARKWAY • CHICAGO 47, ILLINOIS

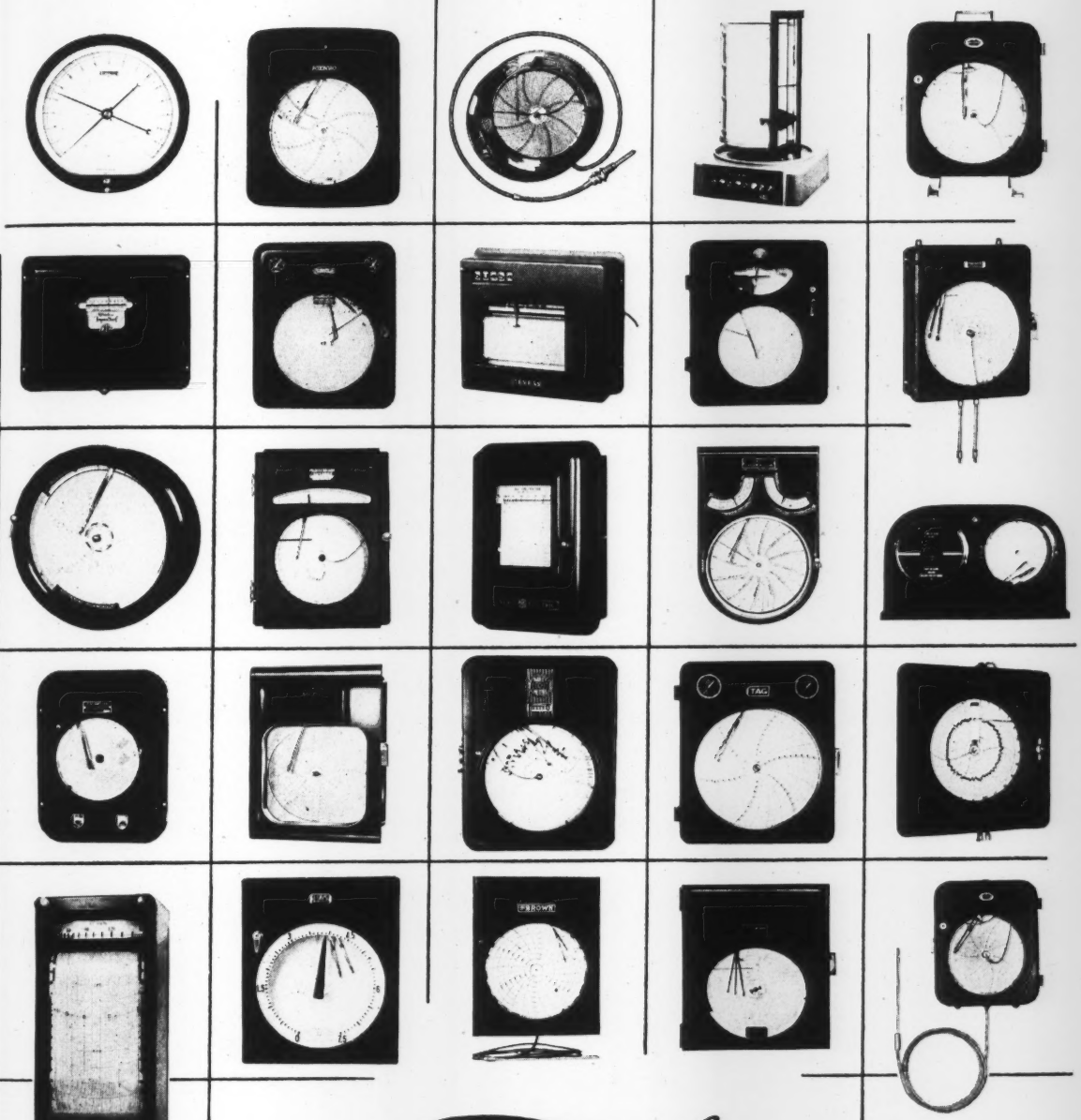
To you...

FOR ANOTHER GREAT YEAR

To you who are engaged in the manufacture of precision instruments, we extend our heartiest salutations for your success in meeting the challenge of the heavy industrial and military demands brought on by war in Korea. Your success can be further measured by the 100% to 300% increase in production of recording instruments alone since the end of World War II (according to SAMA).

We take pleasure in reproducing here a few of the many instruments...each of which includes a Telechron timing motor...representing the technical excellence on which your steady progress is based.

May each succeeding year bring you equally rapid advancement... and count on us, as in the past, for prompt, whole-hearted cooperation at all times. Telechron Department, General Electric Company, 68 Union Street, Ashland, Massachusetts.



Telechron®

ALL TELECHRON TIMING MOTORS ARE

INSTANTLY...CONSTANTLY SYNCHRONOUS

In Control Valve Bodies*, too

The C_Q Method Reveals All the Quality Factors

The C_Q Method enables you to select control valves conveniently — with an accurate analysis of comparative value. First, set a standard of quality; then evaluate *all* the quality factors in relation to your standard. The sum of the value of the quality factors is the C_Q (Quality Coefficient).

"It isn't the first cost — it's the upkeep" is true of control valves. The over-all cost — the real cost — includes maintenance and operation delays in addition to the purchase price. Thus, among comparably priced valves the best buy is the one with a high C_Q — because for comparison purposes

$$\text{Real Cost} = \frac{\text{Price}}{C_Q}$$

"A high quality product provides accurate performance over a long period with a minimum of maintenance and operation delays."

In other words, it has a high C_Q. Use the C_Q Method in selecting *your* control valves.

*This analysis of the valve body assembly is only half the story; write for your copy of an analysis of the diaphragm motor.

Check For These Quality Factors in the Body Assembly

Performance Factor

Flow Characteristics Correct for the Service
Alignment of Parts for Positive Operation and Response
Friction Minimized by Design of Guides, Stuffing Box, Packing, and Plug Stem Finish
Large Body Flow Passage Areas
Long Valve Stroke
C_V (Flow Coefficient) Rating

Mechanical Construction Factor

Strength of Bonnet Construction
Precautions against Seat Ring Distortion
Valve Plug-to-Stem Fastening
Guide Design for Strength and Service Life
Precautions against Misalignment of Parts
Flange Gasket Design
Lubricator Design for Efficiency, Strength, Safety
Stuffing Box Assembly Design
Strength of Bonnet and Blindhead Bolting
Availability of Suitable Body and Trim Design and Materials for the Service
Ability to Withstand Rough Handling

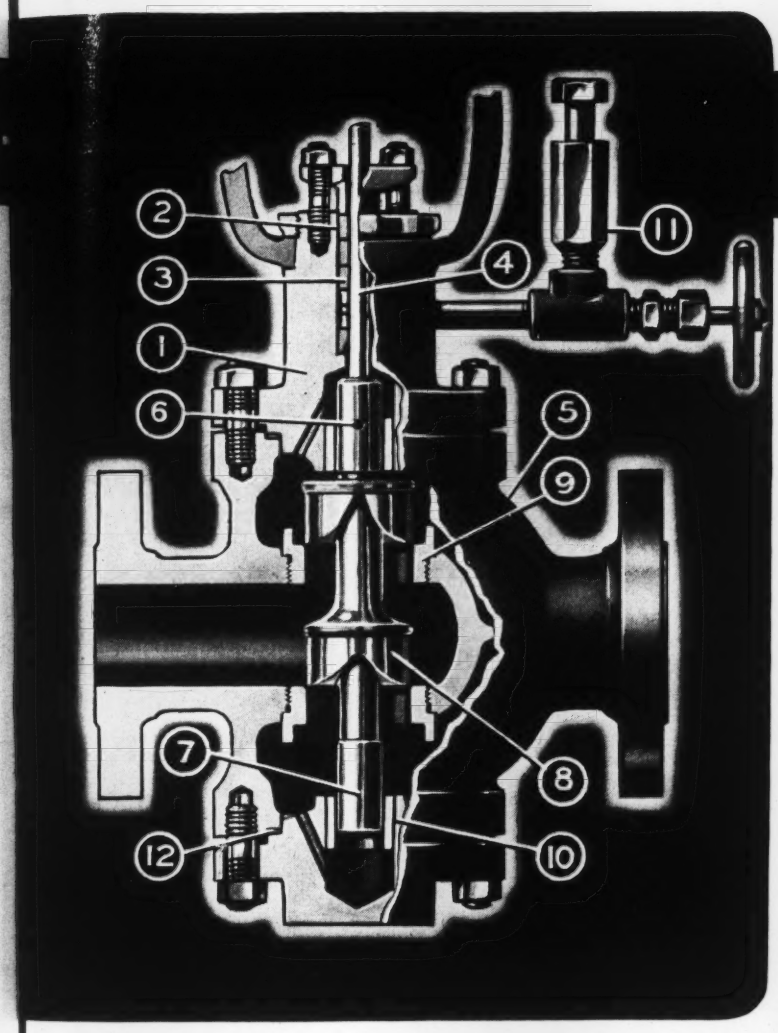
Convenience Factor.

Choice of Body and Trim Materials
Selection of Standard Valve Plug Types
Availability of Standard Reduced Capacity Trim Design
Choice of Standard Packing Materials
Availability of Variety of Bonnet Designs
Standardization of Face-to-Face Dimensions

Maintenance Factor

Ease of Detaching Diaphragm Motor
Ease of Accurate Reassembly after Servicing
Interchangeability of Comparable Parts
Ease of Reversing Plug to change Valve Action

See our Exhibit in Booths 214-216 at the Sixth National Instrument Exhibit, Sam Houston Coliseum, Houston, Texas, September 10-14, 1951.



For Example, Consider the Body Assembly of Masoneilan 10,000 Series Control Valves

1. **One-piece Bonnet** of forged or cast steel, with flange piloted in body for strength and accurate alignment. Heavy bolting for strength.
2. **Bolted Stuffing Box** construction on valve sizes 2" and larger. Threaded construction on smaller valves has five-thread minimum engagement, at no compression, for safety. Adequate box depth for sealing at low compression. Manufactured with special tools and gauges to avoid misalignment, and insure reproducibility and interchangeability of parts. Optimum clearances prevent packing flowing, while allowing for expansion over broad temperature range. Fine finish of gland and box surfaces maintains tightness between packing and box wall. Bonnet extension and air-finned construction available for extreme temperature service; bellows-sealed type for special applications. Bolted construction designed to permit removal of diaphragm motor without disturbing stuffing box.
3. **Four Packing Types** available for application according to service conditions: (1) preformed asbestos-and-binder solid ring; (2) braided-jacket, reinforced plastic core, split ring; (3) woven asbestos, †Teflon-impregnated, split ring; (4) solid †Teflon V-ring.
4. **Honed and Highly Polished Valve Stems** reduce stuffing box friction up to 65%; increase packing life; improve performance.
5. **Body** has large flow passages for minimum pressure drop; bridgewall section designed for heavy seat rings and optimum seat-to-seat distance for rated stroke; has uniform standard face-to-face dimensions in cast iron and steel types.
6. **Stem-to-Plug Fastening** by means of grooved, self-locking pin driven into pinhole drilled and reamed, in stem and plug simultaneously, while stem is threaded tightly into plug — insures tightness, prevents shearing pin.
7. **Heavy Valve Plug Guide** sections manufactured to very close tolerances — insures strength, accurate alignment, reproducibility, interchangeability.
8. **Choice of Plug Types** for practically all services. Includes Percentage Piston, Percentage Parabolic, Percentage V-Port with wide flow range, percentage characteristics. Also quick-opening and linear types, Point-4-Factor reduced capacity trim in solid and V-Port designs. Single and double seated. Interchangeable trim designs in comparable sizes. All types (except Percentage Piston) reversible in field to change valve action.
9. **Seat Rings** with heavy shoulders which prevent distortion; piloting at maximum ring diameter insures positive centering; narrow seating surface in bridgewall and long threaded section provide tight joint, prevent leakage. Four heavy lugs aid in removal and replacement.
10. **Long Guide Bushings** (steel valves) of hardened stainless steel in bonnet and blindhead have minimum clearance, assure accurate guiding.
11. **Lubricator** size is ¼" minimum for strength; has ball check valve. Forged steel isolating valve supplied with steel valves for added safety.
12. **Fully Retained Gaskets** of corrugated armco iron or special alloy for tightness and durability.

Accurate Alignment
assured by piloted bonnet, blindhead, and seat rings; by precision control of stuffing box, guide bushing, plug guide section clearances; by manufacture with special tools and gauges for exact reproducibility of all parts.

†Teflon is a trademark of E. I. du Pont de Nemours & Co.

THE MASONEILAN 10,000 SERIES CONTROL VALVE IS

A High C_Q Product

MASON-NEILAN REGULATOR CO.

1210 Adams Street, Boston 24, Mass., U. S. A.

Sales Offices or Distributors in the Following Cities

New York • Syracuse • Chicago • St. Louis • Tulsa
Philadelphia • Houston • Pittsburgh • Atlanta • Cleveland
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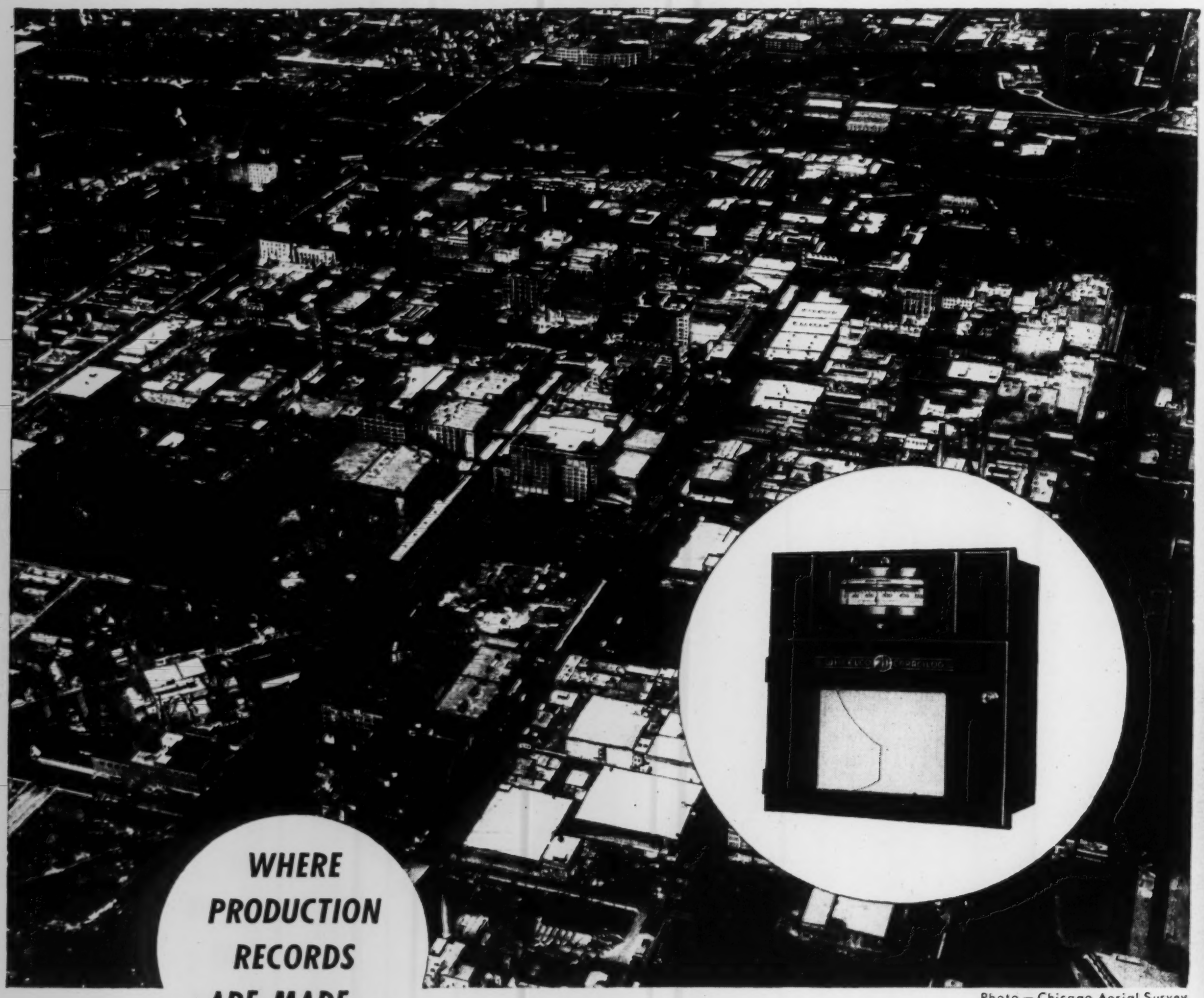
Mason-Neilan Regulator Co., Ltd., Montreal and Toronto

)U CAN INSURE FULL C_V WITH A HIGH C_Q



WHERE PRODUCTION RECORDS ARE MADE...

Photo—Chicago Aerial Survey

the wheelco recorder

Here's the Central Manufacturing District of Chicago—where more than 360 industries, concentrated in less than 1½ square miles, manufacture thousands of different products. Yes—here where production records are made and kept—the Wheelco Capacilog is invaluable for measuring, indicating, controlling and recording electrically measurable variables.

Specify the Wheelco Capacilog, a deflection type strip chart recorder that gives you accuracy to ¼ of 1% of total scale—suppressed scales with a built in reference point—Thermocouple Break Protection that completely eliminates "residual error". Capacilogs are built for use with thermocouples and resistance thermometer measuring elements; as single or multipoint recorders, and with six different control combinations including pneumatic and electric proportioning types.

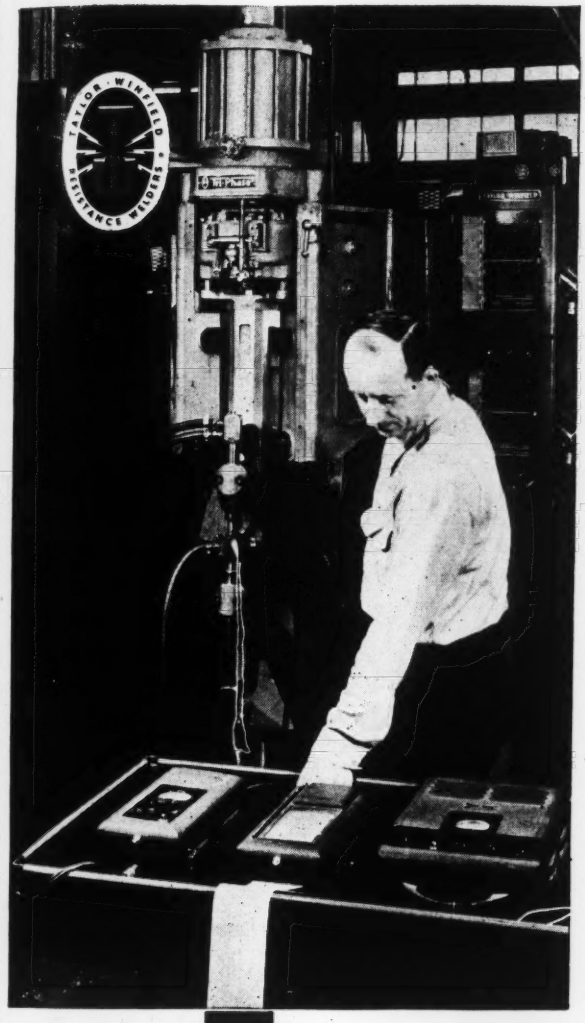
Assembly line production and simplicity of construction make it possible to deliver most models within 20 days.

instrumentality When you specify Wheelco you specify *Instrumentality*—Wheelco's ability to design and build efficient and economical instruments to fulfill your needs for accurate and dependable control and recording.

Visit the Wheelco Booth #326-328, 6th National Instruments Exhibit, Sam Houston Coliseum, Houston, Texas, Sept. 10-14.

Wheelco Instruments Company, 833 W. Harrison Street, Chicago 7, Illinois

wheelco *electronic controls*



welding specifications a problem?

BRUSH ANALYZER RECORDS WELDING CURRENT AND TIME EXACTLY

● The Taylor Winfield Corporation, manufacturer of resistance, spot, seam, and butt welders, makes sure of correct current and timing calibration on each spot welder before shipment.

While a sample weld is being made, a Brush Analyzer records amplitude and timing of both input current and welding current on the same chart. By observing the wave shapes, Taylor Winfield inspectors calibrate controls quickly and surely. Production time is saved, and correct results assured.

Maintaining welding specifications is difficult with "rule-of-thumb" adjustment, particularly on metals such as aluminum. Brush Analyzers can give you written proof of welding currents, or of electrode pressures.

Investigate Brush instruments for studies of d-c or a-c voltages or currents, strains, displacements, light intensities, temperatures, and other static or dynamic conditions. Write for information. The Brush Development Company, Dept. A-5, 3405 Perkins Avenue, Cleveland 14, Ohio, U. S. A. *Canadian Representatives:* A. C. Wickman (Canada) Limited, P. O. Box 9, Station N, Toronto 14, Ontario.

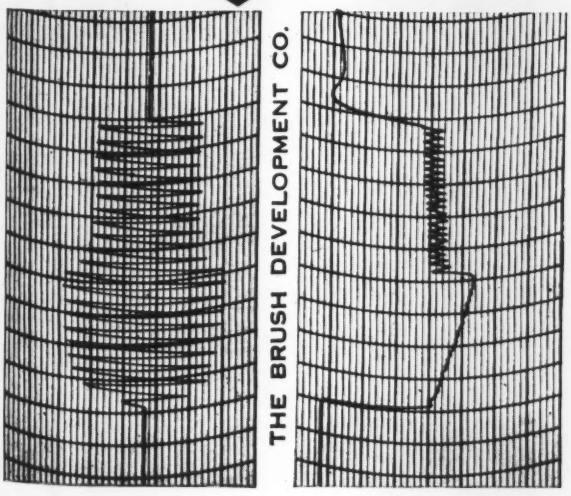


Chart of welding cycle on Taylor Winfield welder shows 60-cycle A-c input current at left, D-c welding current at right. This Brush Analyzer consists of A-c amplifier, D-c amplifier, direct-writing oscillograph.

Put it in writing with a
BRUSH RECORDING ANALYZER

THE *Brush* DEVELOPMENT COMPANY

PIEZOELECTRIC CRYSTALS AND CERAMICS • MAGNETIC RECORDING
ELECTROACOUSTICS • ULTRASONICS • INDUSTRIAL & RESEARCH INSTRUMENTS

Century INDUSTRIAL

FOR VIBRATION, STRESS, TEMPERATURE,

MODEL 408 OSCILLOGRAPH

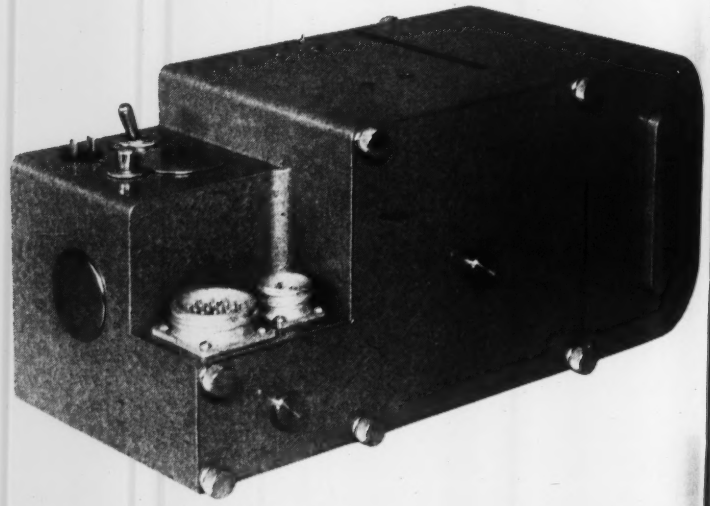
The Century Model 408 recording oscillograph was designed expressly for airborne and mobile operation. As with all Century products, this oscillograph incorporates the utmost in design and workmanship, along with improved features, yet it remains simple in its operation and maintenance.

FEATURES:

Size: 20" long, 12½" wide, 8⅞" high.
Weight: 51 pounds.
Number of Recording Channels: 6 to 48.
Detachable daylight loading magazine accommodating a roll of paper or film 8" x 200'.
Friction roller type paper drive by governor controlled electric motor with separate motor for takeup drive.
Paper speeds continuously and instantly variable without changing gears or sprockets.
Separate optical system for viewing before or during recording.
Glow tube timing system photographing .01 second and .1 second lines. .01 second lines instantly removable by toggle switch for slower speeds.
Data numbering at beginning of record.
Footage indicator showing amount of paper remaining in magazine.
Automatic record length control.
Trace identification.
Remote control unit.

MODEL 409 OSCILLOGRAPH

The Century Model 409 oscillograph has been designed for recording data where space and weight requirements are limited. This oscillograph has been tested to record faithfully while subjected to accelerations up to 20 G's.

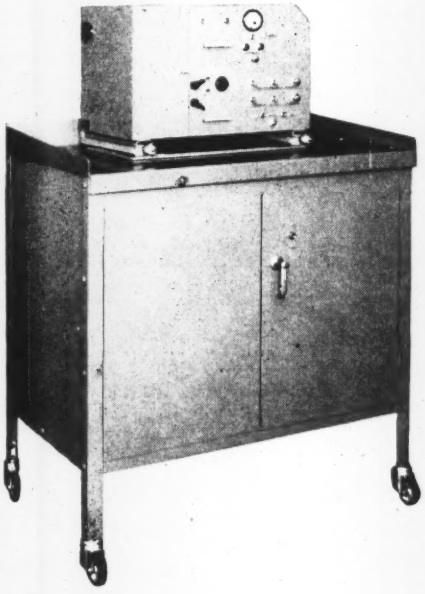


FEATURES:

Size: 5" x 5" x 11".
Weight: 11 pounds.
Cast Aluminum case.
Paper speeds instantly variable ½" to 6" and 2" to 12" per second.
Detachable daylight loading magazine with a capacity of 3⅝" x 50' or 3⅝" x 100' paper. 2 to 12 individual channels.
Trace identification.
Trace viewing.

RECORDING EQUIPMENT

STRAIN ANALYSIS, and other Applications



MODEL 406 OSCILLOGRAPH

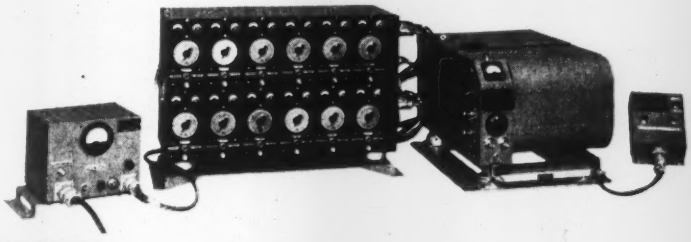
The Century Model 406 oscillograph is one of the finest laboratory instruments available. This unit will accommodate up to 48 individual channels and still incorporates all of the preferred features.

FEATURES:

Size: 12½" x 13½" x 22".
Weight: 90 pounds.
Continuously variable speed control without gear change.
Temperature compensated fork controlled timing system using a glow tube.
Separate paper takeup magazine allowing any length of recording up to 200 ft. without jamming.
Magazine capacity of 8" x 200' roll of paper or film.
Separate optical system for trace viewing and scanning.
Automatic record numbering at beginning of record.
Paper footage indicator.
Automatic record length control.
Remote control unit.
Available for 24 volt d.c. or 115 volt a.c. operation.

MODEL 508 LINEAR-INTEGRATING AMPLIFIER

With Power Supply, Model 408 Oscillograph and Remote Control



FEATURES:

Frequency response flat ± 5% from 3 cps to 3,000 cps or ± 2% from 5 cps to 2,000 cps.
Frequency response linear ± 5% from 5 cps to 2,000 cps or ± 2% from 7 cps to 2,000 cps.
Individual output metering.
Overload indicator.

GALVANOMETERS

All Century oscillographs are equipped with Century Model 210 galvanometer elements. These elements are available over a wide range of frequencies and sensitivities and in most instances are easily adaptable to other makes of oscillographs. Each element is electrically isolated.

FEATURES:

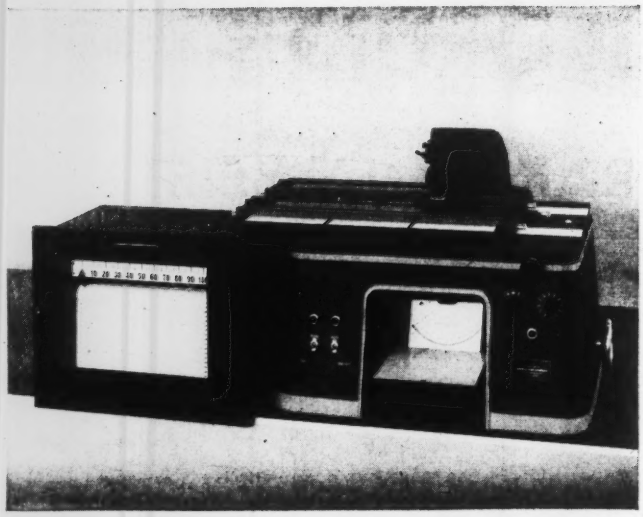
Small, tubular type construction with rotating pole pieces flush with case. This allows correct flux angle for any horizontal position and eliminates stressing the suspension for horizontal adjustment.
Hermetically sealed.
Horizontal and vertical optical adjustment readily accomplished.
Plug-in mounting, elements may be replaced or interchanged with minimum effort.
Negligible zero drift as a function of temperature.

Century GEOPHYSICAL CORPORATION
TULSA, OKLAHOMA

1505 Race Street
Philadelphia, Pa.

EXPORT OFFICE:
149 Broadway, New York

Here's the Instrument you built!



JACO BALANCED BEAM

Projection Comparator Recording Microphotometer

You asked for increased sensitivity and higher resolution . . . for a *proven* high speed recording device . . . for construction features that would speed your work and make it easier too. Now *all* these advantages—and many more—are here . . . in the new Jaco Projection Comparator Recording Microphotometer. Check these outstanding advantages against the work you are now doing:

• Monitoring light beam eliminates effect of voltage fluctuations • Adjustable entrance slits (as small as the equivalent of lu x 100u at the plate) guarantee exceptional flexibility and resolution • High speed (0.7 sec.) Brown Electronik chart recorder • Stability achieved by use of double beam technique with single detector • Reproducibility of $\pm 1\%$ • Choice of 12 scanning speeds, either forward or reverse • Linear measurement on plate or film to 0.01mm.

Space limits listing the many other outstanding features of this truly remarkable new instrument. For all the facts write for Bulletin 203Y today.

ON EXHIBIT BOOTH 625 AT THE HOUSTON INSTRUMENT SHOW

JARRELL-ASH COMPANY
165 NEWBURY ST. BOSTON 16, MASS.

Boston Detroit Chattanooga San Francisco Toronto

If it's an optical instrument, think of Jarrell-Ash

How CLARE Engineers improved the performance of a relay without increasing its size

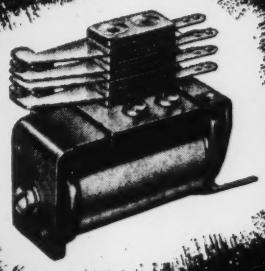
SAME VIBRATION RESISTANCE

SAME CONTACT PRESSURE

SAME FAST OPERATION

SAME SMALL SIZE

CLARE Type "KX" RELAY



GREATER OPERATING RANGE

GREATER SENSITIVITY

SPECIFICATIONS

Size: Length: $1\frac{39}{64}$"; Height: $1\frac{13}{32}$"; Width: 1". Dimensions vary with type of coil terminal used. Height shown is maximum (with 8 springs in pileup). **Weight:** Approx. 2 oz. **Coil:** Single or double wound. **Operating Voltage:** to 175 volts d-c. **Armature:** Single- or double-arm. **Contact Arrangement:** Forms A to C available. Maximum 8 springs in pileup. **Mounting:** Two #4-40 screws. Can also be furnished with 2 or 4 mounting studs tapped for #4-40 screws.

● The Clare Type "K" Relay, first of the famous Clare line of small, lightweight, telephone-type relays, is still the mainstay of design engineers who must have superior relays to operate in extremely small space.

Its fast operation, adequate contact pressure, high resistance to shock and vibration, long life and complete all-around dependability have met many complex requirements. Once in a while, however, Clare engineers have been confronted with customers' specifications which this Clare Type "K" Relay would not quite meet.

More often than not this was due to the small spool which limited coil winding to a maximum of 6500 ohms. Clare engineers have met this situation with the new Type "KX" whose sensitivity and operating range are increased by use of a slightly longer coil which can be safely wound to a maximum resistance of 8000 ohms. This additional winding space is gained by a slight change in the design and suspension of the armature which enables the length of the coil to be increased without adding materially to the over-all length of the relay.

The Type "KX", like the Type "K" and Type "R" relays, has the reed armature suspension of special alloy which engineers recognize as one of the subtler reasons for the superior performance of these small Clare relays. The Type "KX" is interchangeable with the Type "K" for mounting.

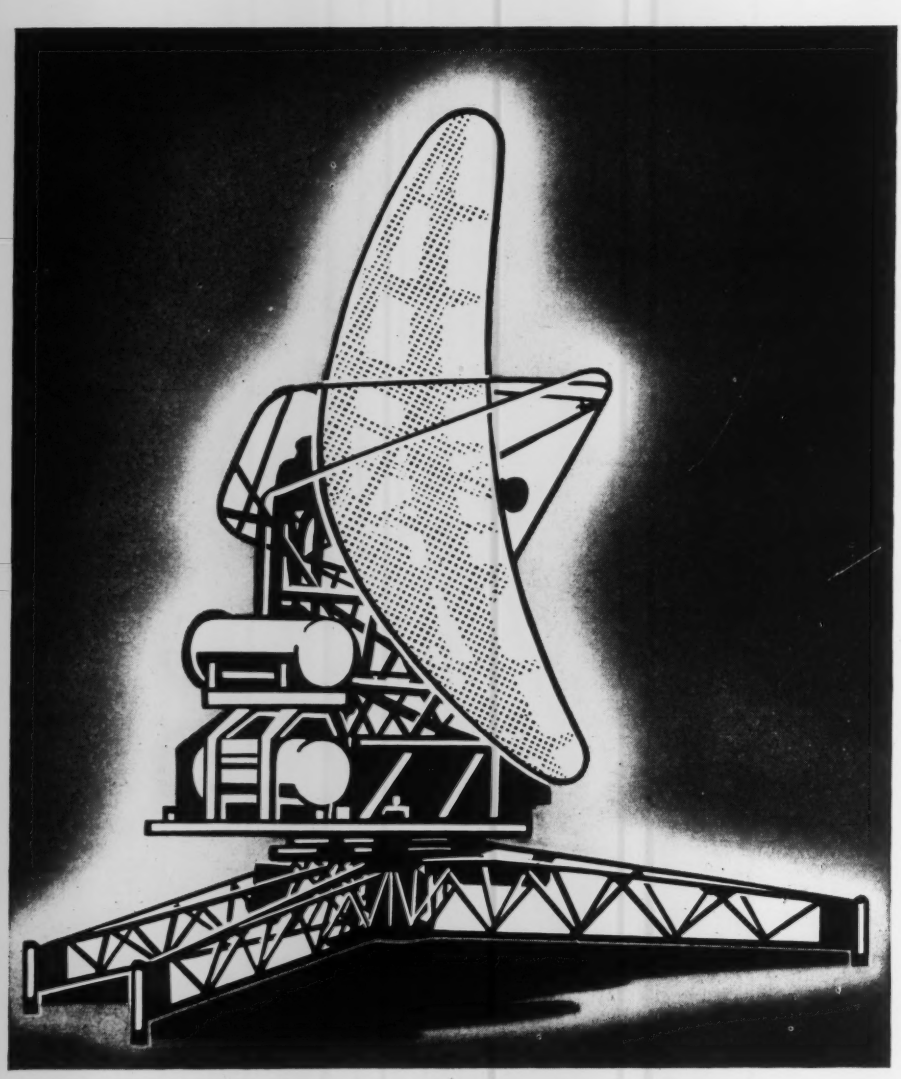
This new relay is available as either an open or hermetically sealed relay. Call your nearest Clare sales engineer . . . located in principal cities to serve you . . . or write C. P. Clare & Co., 4719 West Sunnyside Avenue, Chicago 30, Illinois. In Canada: Canadian Line Materials, Ltd., Toronto 13. Cable Address: CLARELAY.

Write for Clare Bulletin No. 116

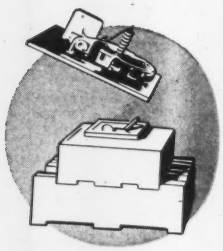
CLARE RELAYS

First in the Industrial Field

CARBOLOY Alnico

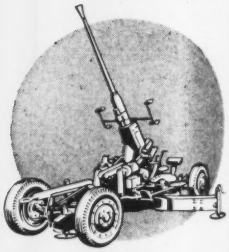


RADAR EQUIPMENT

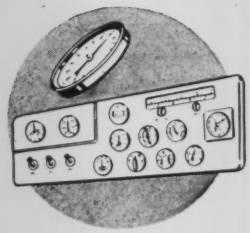


CONTROL EQUIPMENT

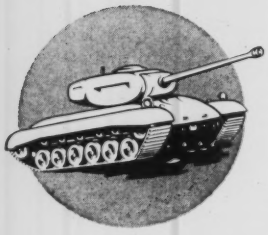
MILITARY COMMUNICATIO EQUIPMENT



ANTI-AIRCRAFT GUNS

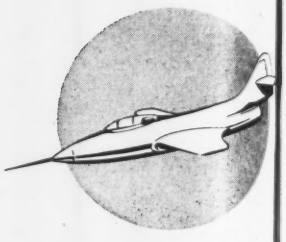


METERS AND INSTRUMENTS



TANKS

TELEPHONES



PLANES

Permanent Magnets

Picked for the VITAL jobs

because they're quality-made for lasting energy

WHERE uniform quality is a must, Carboloy Permanent Magnets get the call.

Carboloy Alnico Permanent Magnets in radar and communications equipment, aircraft generators, instruments, meters, motors, compasses, control equipment and countless other essential products have proved that Carboloy made means quality made. The finest permanent magnets anywhere for uniform, lasting energy . . . every one individually checked and re-checked to top-quality standards by skilled personnel.

Dependable as the magnets themselves, is our delivery promise. Once your order is accepted and scheduled, Carboloy magnets arrive at your plant . . . on time, as specified.

EXPERT ENGINEERING SERVICE

Carboloy Permanent Magnets are available to meet your defense and essential needs. And we're ready to give the same careful attention to your magnet problems that we give to the production and delivery of the magnets themselves. Why not call on our engineers? Write us today:

Carboloy Department of General Electric Company, 11155 East 8 Mile Street, Detroit 32, Michigan.

CARBOLOY

ALNICO PERMANENT MAGNETS

"Carboloy" is the trade-mark for the products of Carboloy Department of General Electric Company

FIRST IN MAN-MADE METALS FOR BETTER PRODUCTS

One OF A LINE...

APPROVED BY THE AIR FORCE FOR *Dependable Control*

The SCREW TERMINAL TYPE CONTAINER

Provided with either back or bottom mounting brackets. Barrier type face plates prevent short circuits between cable and terminal lugs. Easy access to terminal for circuit revisions is possible since, as in the Lug Header Type, removal of the relay from the equipment is not necessary. This unit has particularly wide applications in the aircraft industry.

The Series 335 D.C. (AN-3316-2) Guardian Relay is one of a line of famous controls which distinguish Guardian Electric as a dependable supplier to the U. S. Air Force. *Hermetically sealed* (AN-3312) to (MIL-5757) specifications, or with conventional open and special mountings, Series 335-D.C. offers a wide variety of aircraft applications. Built to rigorous aviation standards, it meets the ANR-20-B and the MIL-R-6106. Generous coil winding area permits single windings up to 15,000 ohms. Parallel and double windings available.

Maximum voltage: 220 v., D.C. Power requirement: Normal, 3½ watts. Max. resistance standard unit: 12,000 ohms. Applicable to time delay attract up to .06 second and release up to .01 second. Contact rating: ¼" dia. silver, 12 amps, at 24 v., D.C. inductive load. Combinations up to 4 P.D.T. with 12 amp. contacts. Bakelite insulated, tested at 1,500 v.—60 C.

GUARDIAN'S NEW HERMETICALLY SEALED RELAY CATALOG IS YOURS FOR THE ASKING

Series 30 A.C.

Series 210 A.C.—215 D.C

Series 220 A.C.

Series 595 D.C.

Series 610 A.C.—615 D.C.

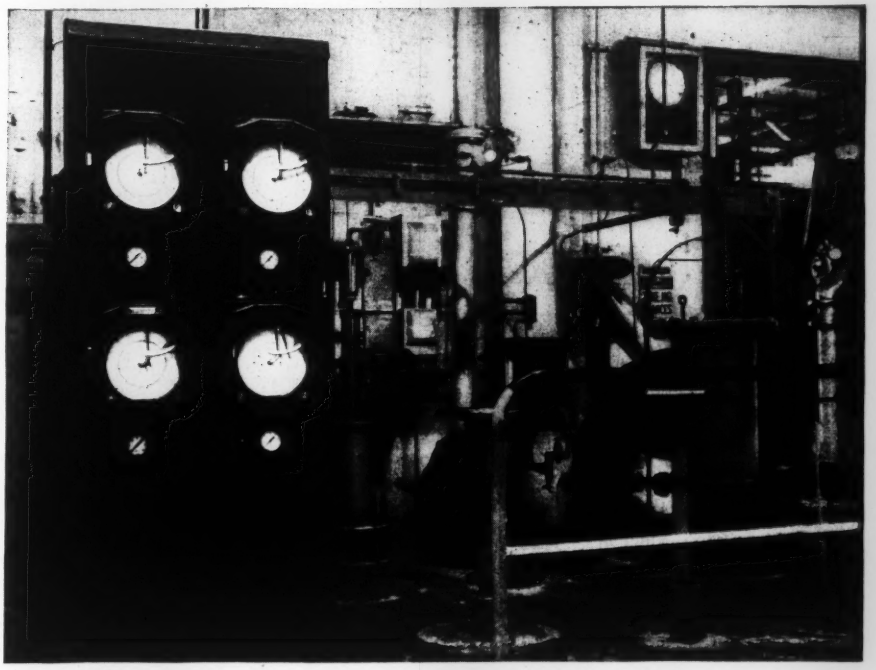
SUBMIT YOUR BLUEPRINTS FOR SPECIFIC RECOMMENDATIONS—WRITE

GUARDIAN ELECTRIC

1638-J W. WALNUT STREET CHICAGO 12, ILLINOIS

A COMPLETE LINE OF RELAYS SERVING AMERICAN INDUSTRY

Today's most flexible and dependable AUTOMATIC FLOW RATIO CONTROLLER



A panel of three F&P Ratio-Controllers blending wood pulp slurry with one additional recording-controller. Also shown are large-capacity RATOSLEEVE flow meters and control valves.

● WIDE RANGE OF APPLICATION

A choice of F&P primary elements is available to handle a range of flows as low as 4-40 cc/min liquid for pilot plant blending or treating-reagent additions to any measurable high capacity flow in closed or open channels.

● WIDE RANGE OF MEASUREMENT

The wide-range linear flow scales of F&P primary elements permit outstanding rangeability of flows under all conditions—not merely at or near design ratio.

● WIDE RANGE OF SETTING

Controlled flow can be in any desired ratio to "wild" or uncontrolled flow. Ratio selector scales are graduated from 15% to 600% (scale length is 7"). Pneumatic-set ratio is available for applications such as pH control. Vernier adjustment can be supplied for extreme precision of setting.

● COMPLETE RATIO-CONTROL SYSTEM

Full responsibility for the proper coordination and smooth performance of the various components of the system is vested in Fischer & Porter, manufacturer of the primary elements (FLOWRATOR meters, V/A Cell Kinetic manometers, and others)—secondary elements (RATOMATIC control instruments) — and VALVRATOR control valves.

Fischer & Porter offers a complete system for proportioning the flows of fluids (liquids, gases, slurries) in two or more pipe lines. The various elements utilize electrical, electronic or pneumatic transmission systems in any suitable combination. These systems can be readily tied in with machine speeds, positive displacement meters, metering pumps, or dry feeders.

WRITE FOR CATALOG 53

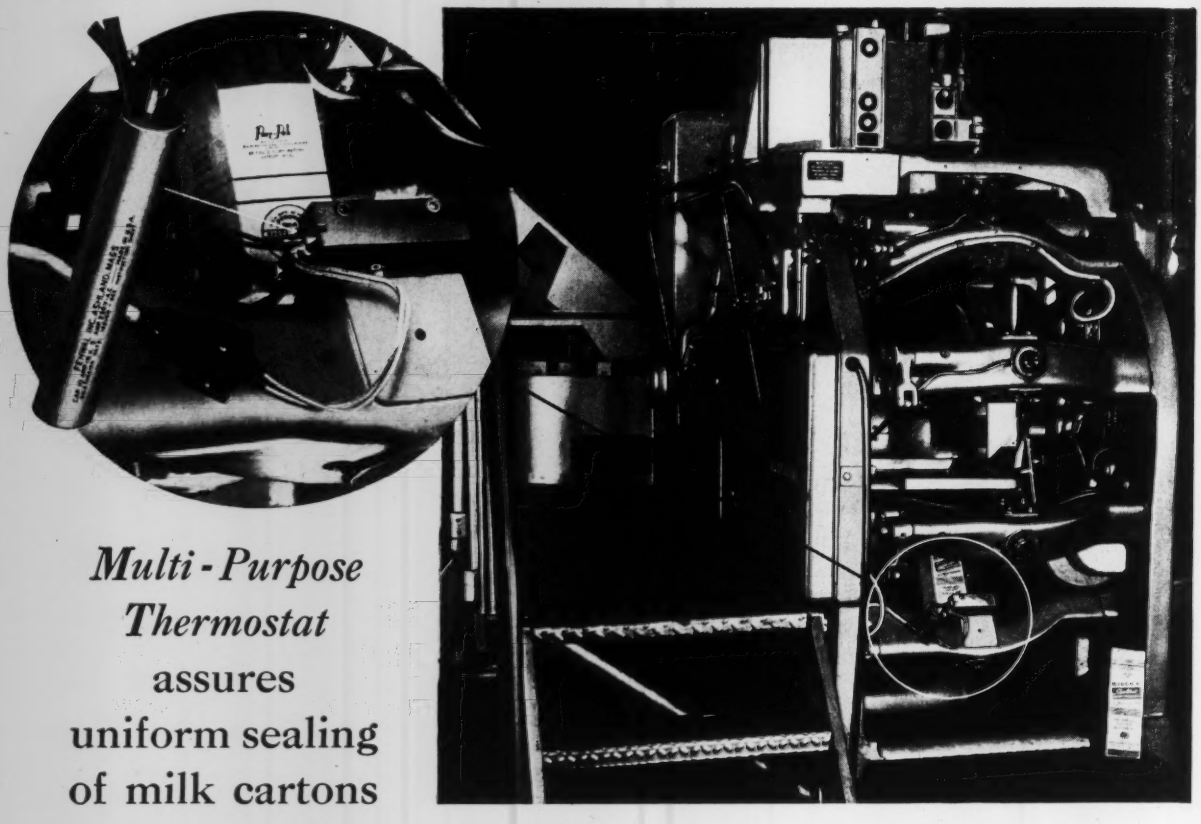
PROCESS CONTROL INSTRUMENTS

FLOWRATOR

FISCHER & PORTER COMPAN

HATBORO, PENNSYLVANIA, U.S

SALES ENGINEERING OFFICES THROUGHOUT THE W



Multi-Purpose Thermostat assures uniform sealing of milk cartons

When famous Pure-Pak milk cartons were designed, a basic step in their formation was the proper sealing of the bottom flaps. The sealing was done by contact with an electrically heated block and this block had to be kept at a uniform sealing temperature.

The problem was solved when Pure-Pak, a division of the Ex-Cell-O Corporation in Detroit, installed low cost Fenwal THERMOSWITCH thermostats as the temperature control units. These thermostats provide positive control, minimum maintenance, are sufficiently compact to fit efficiently on the Pure-Pak carton-forming machine. Now dairies throughout the country benefit from the sealing uniformity assured by Fenwal THERMOSWITCH Thermostats.

The dairy industry is but one of many to benefit from Fenwal THERMOSWITCH units. They effectively control many variables where heat is a factor.

Their unique principle of operation consists of a single-metal activating shell. This shell expands or contracts *instantaneously* with temperature changes, making or breaking the totally enclosed electrical contacts.

Fenwal THERMOSWITCH Thermostats can no doubt help you in your own processing. Find out how by mailing the coupon today.

Visit our Booth 206 at the National Instrument Exhibit, Houston, Texas

Fenwal

THERMOSWITCH®

The Precision, Multi-Purpose, Thermostat Control

SENSITIVE . . . but only to heat

FREE! **Get this bulletin . . . see what Fenwal THERMOSWITCH units can do for you.**

Just fill in coupon and mail . . . no obligation.

FENWAL, INCORPORATED, 178 Pleasant St., Ashland, Mass.
111 South Burlington Ave., Los Angeles 4, Cal.

TEMPERATURE CONTROL ENGINEERS

Name ..... Position .....

Company .....

Street .....

City ..... Zone ..... State .....

I am chiefly interested in the applications checked:

- ☐ Heating
- ☐ Cooling
- ☐ Humidity Control or Detection
- ☐ Alarm (over-temperature, under-temperature)
- ☐ Vapor Control
- ☐ Timing (thermal)
- ☐ Radiant Heat Control
- ☐ Pressure Control (by controlling vapor temperature)

OTHER (Please fill in your special requirements) .....

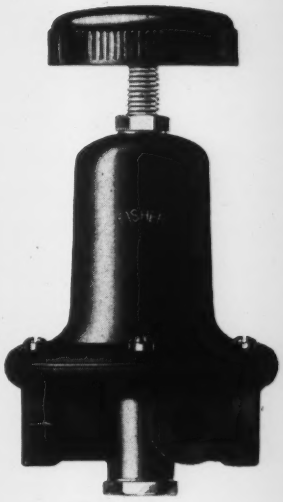
.....

.....

★We'll see you at Booth 523-525-527 at the Instrument Show in Houston, September 10 to 14.

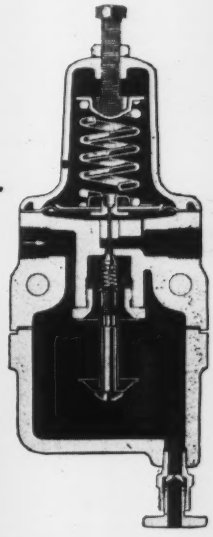
Nationwide Swing to

FISHER® SERIES 67
SMALL VOLUME REGULATORS



FISHER TYPE 67

exterior view, with hand-wheel adjusting screw. Also available as Type 67P for panel mounting.



FISHER TYPE 67FR

combination filter regulator. Finest filter perforation area-0.002".

AN ALL-PURPOSE REGULATOR PARTICULARLY ADAPTED AS AN AUXILIARY OPERATING MEDIUM PRESSURE REGULATOR

- **ACCURATE, EFFICIENT REGULATION**
- **TIGHT CLOSURE**
- **WILL NOT CHATTER, VIBRATE OR SING**
- **NEAT DESIGN**

Fisher Series 67 Regulators have won universal acceptance for small volume air or gas flows. They are ideal for hundreds of industrial applications and are particularly adapted to instrument air service, supplying 20 lbs. operating medium pressure to pilot operated regulators. Capacity up to 6 C.F.M. For further details and complete specifications, write for Fisher Bulletin 67, **Fisher Governor Company, Marshalltown, Iowa.**

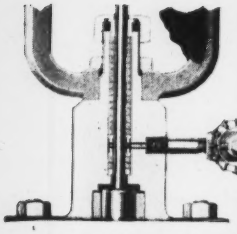
FISHER®

LEADS THE INDUSTRY IN RESEARCH FOR BETTER PRESSURE CONTROL

COMPARE

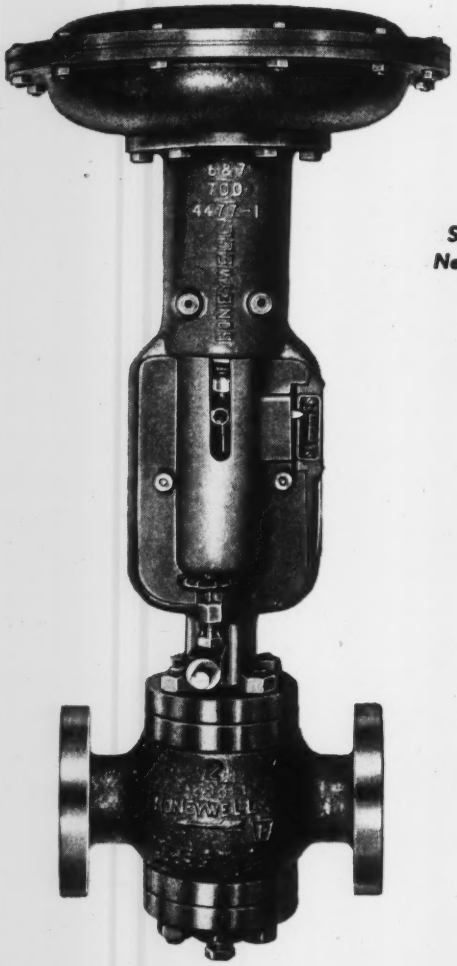
THIS FEATURE

OF THE HONEYWELL SERIES "700" VALVE



ONE-PIECE BONNET

One-Piece Bolted Bonnet of forged steel provides greater ruggedness, simplifies removal for maintenance. Stuffing box is an integral part of bonnet, depth at least six times diameter of stem. Lantern Gland is double packed (top and bottom) . . . added protection against leakage.



Specially Designed Neoprene Diaphragm

Duplex Upper Stem Guide

Packless Bellows Seal

Safety Stem Lubricator

Wide Variety of Discs

Reversibility in the Field

✻ Compare the bonnet of this valve with that of any other wide band proportional type. Look at it closely . . . study it feature by feature.

Then check the other features of the valve . . . the Specially Designed Diaphragm, the Duplex Stem Guide, the Packless Bellows Seal, the Safety Stem Lubricator, the wide variety of discs, the easy reversibility in the field.

Your comparison will prove that the Honeywell Series 700 has *all* the features you look for in a fine valve.

It's available in a wide range of styles and sizes. For detailed information, write for a copy of Catalog 700-2, or call in your local Honeywell engineer . . . he is as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, 1908 Windrim Ave., Philadelphia 44, Pa. Offices in more than 80 principal cities of the United States, Canada and throughout the world.

New Bulletin 750, "Control Valve Sizing Data," is now available

MINNEAPOLIS **Honeywell**

VALVE PRODUCTS

Triplett

Model 630

There is no more useful and dependable instrument made

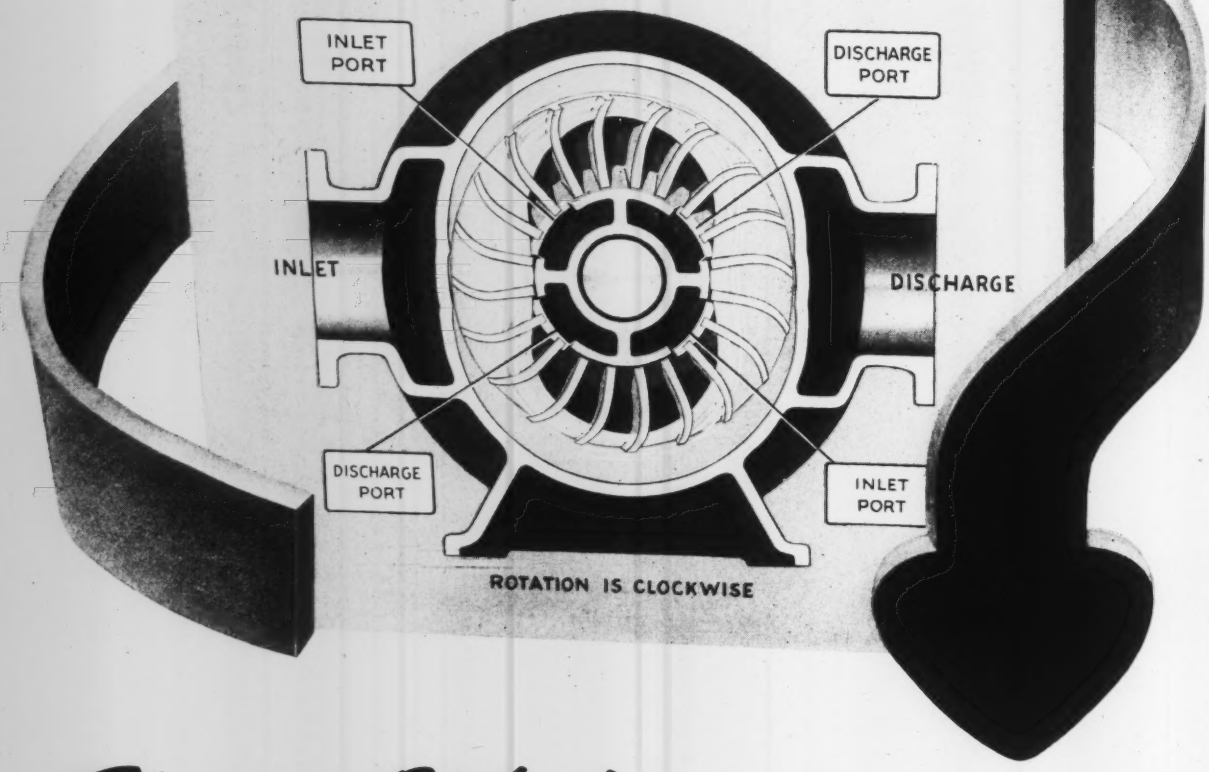
FOR THE MAN WHO TAKES PRIDE IN HIS WORK

ONLY $39.50 AT YOUR DISTRIBUTORS
Prices Subject to Change

Triplett

TRIPLETT ELECTRICAL INSTRUMENT COMPANY · BLUFFTON, OHIO, U S A

Nash Instrument Air Compressors deliver only clean air, free from oil or dust, and without filters



Here is Why!

You can dispense with oil filters and dust filters when you install ®Nash® Clean Air Compressors. You can save the cost of maintaining these devices. You can greatly reduce instrument maintenance costs. For the Nash employs no internal lubrication, therefore no troublesome oil is in the delivered air. Moreover, air from a Nash is thoroughly washed and cooled as it passes thru the pump. Dust in the plant atmosphere, even fly ash, is immediately removed.

®Nash® Clean Air Compressors are simple, with only one moving element. No valves, gears, pistons, sliding vanes, or other enemies of long life and constant performance complicate a Nash. No aftercoolers are needed. You will find it profitable to investigate these pumps, now.

No oil filters.
No dust filters.
No internal lubrication to contaminate air handled.
No internal wearing parts.
No valves, pistons, or vanes.
Non-pulsating pressure.
Original performance constant over a long pump life.
Low maintenance cost.

NASH ENGINEERING COMPANY
396 WILSON, SO. NORWALK, CONN.

Here's How to Erase Smoke Troubles

VIOLATION OF SMOKE ORDINANCE

LOSS OF FUEL ECONOMY

BAD COMMUNITY RELATIONS

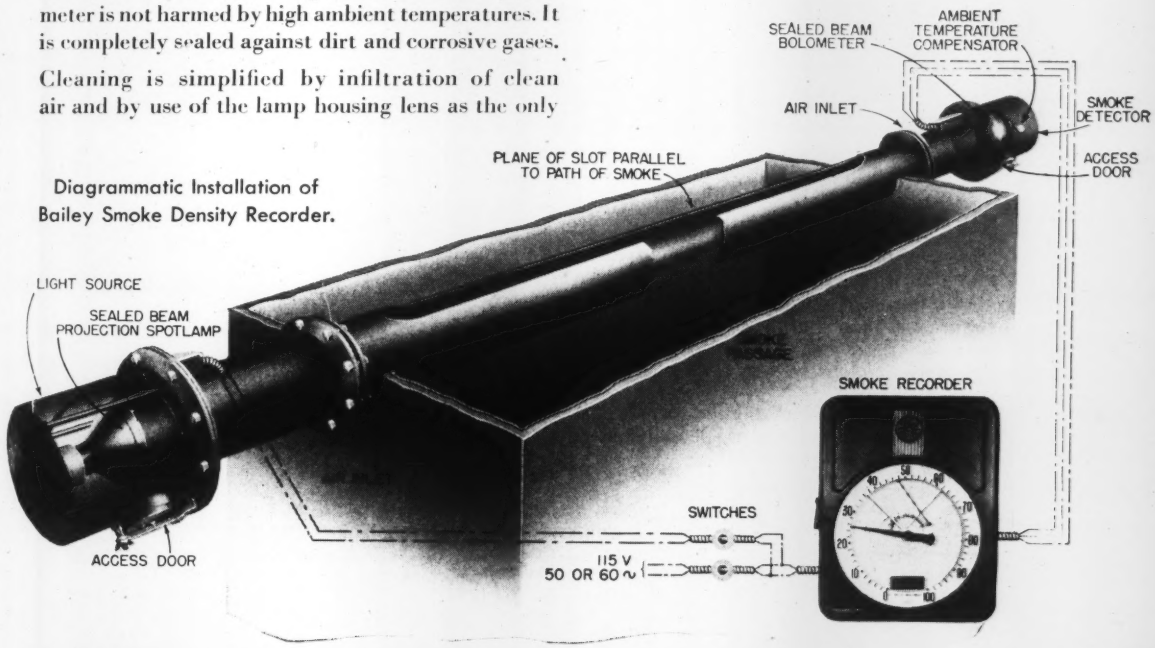
★ One of your first steps in erasing these troubles which result from excessive smoke, should be the installation of a Bailey Smoke Density Recorder. This 24-hour recorder is not an ordinary photo-cell instrument. Instead it detects smoke density by a Bolometer which is simply a sturdy tungsten filament and a parabolic mirror, mounted in a standard sealed beam automobile head lamp housing.

In using this simple, unique smoke detector, you do not have to provide cooling devices since the Bolometer is not harmed by high ambient temperatures. It is completely sealed against dirt and corrosive gases.

Cleaning is simplified by infiltration of clean air and by use of the lamp housing lens as the only window between the Bolometer and the gas passage.

It's easy to secure and maintain alignment of the sealed beam light source with the Bolometer since they are mounted at opposite ends of a slotted pipe which extends across the smoke passage.

For complete information on how you can profitably use this unique instrument to erase your smoke troubles, ask for Bulletin 211, "Bailey Smoke Density Recorder".



Diagrammatic Installation of Bailey Smoke Density Recorder.

G-29

BAILEY METER COMPANY

1041 IVANHOE ROAD, CLEVELAND 10, OHIO • BRANCH OFFICES IN PRINCIPAL CITIES

BAILEY METER COMPANY LIMITED, MONTREAL, CANADA

Let Bailey Smoke Density Recorders Watch Your Stacks

Your Best PROTECTION...

TRADE LESLIE MARK

SELF-CLEANING STRAINERS

DIRT — DIRT — DIRT —
RUST — RUST — RUST —
SCALE — SCALE — SCALE
CLEAN FLUID
... against
DIRT-RUST-SCALE
DIRT RUST SCALE
LESLIE Strainer Screens have large, free area to insure ample flow and straining capacity.
Stop valve connected to Strainer blowoff can be opened, allowing flow of operating fluid to cleanse screen.

Complete *protection* for Reducing Valves, Pump Governors, Temperature Regulators, Turbines, Pumps, Traps, Valves and other equipment against dirt, rust and scale is provided at lower cost by LESLIE Self-Cleaning Strainers.

Protection from foreign material increases the life of equipment and prevents costly down-time. Large free area permits good cleaning with low pressure loss through the Strainer. Self-Cleaning feature allows cleaning of screen without removal from strainer body or shutting off operating fluid.

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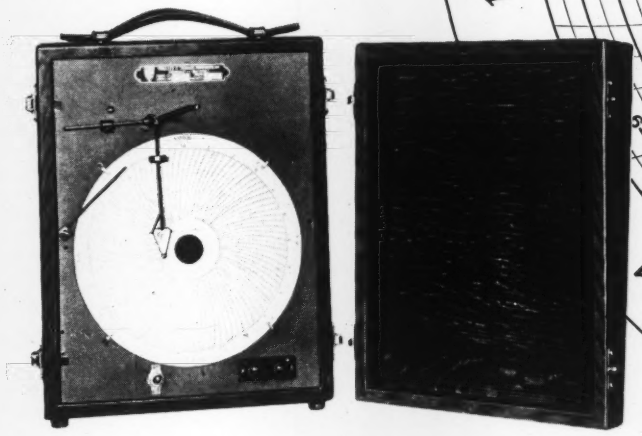

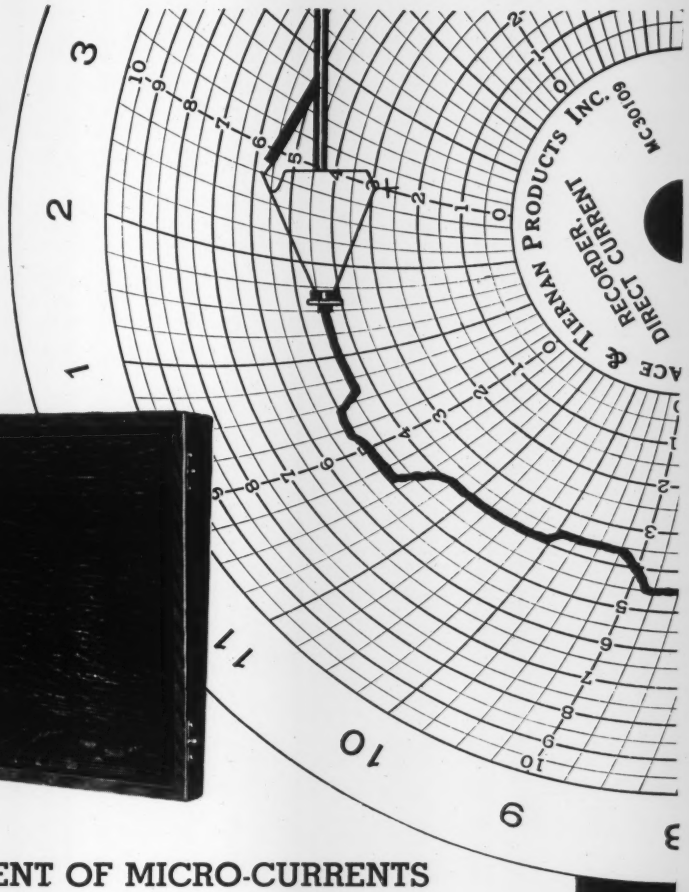

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Sensitivity . . .	1 part in 1000 of full scale range.	Chart Diameter .	8 inches.
Minimum Range .	0 to 100 microamperes.	Chart Speed . .	1 revolution per 24 hours.
Maximum Range .	0 to 6.0 amperes.	Case	Highly finished hard wood.
Coil Adjusting Range . . .	2.3 to 25 ampere turns.	Size	13" high by 10⅛" wide by 5½" deep.
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A-87

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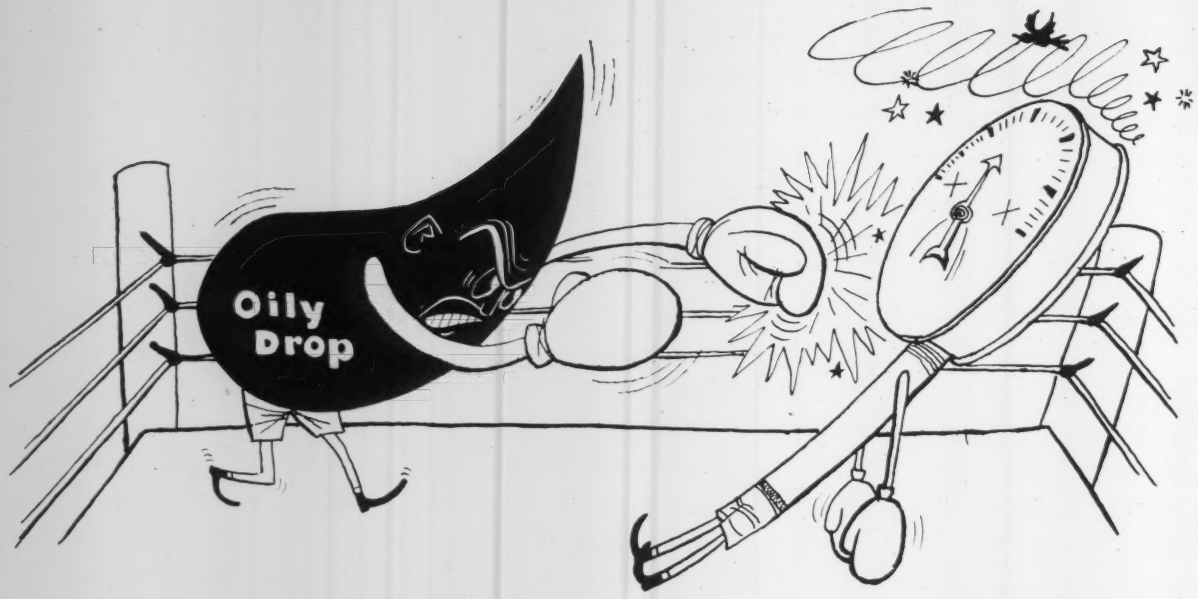

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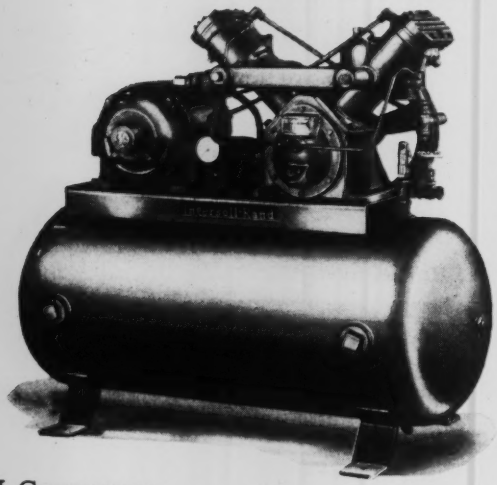
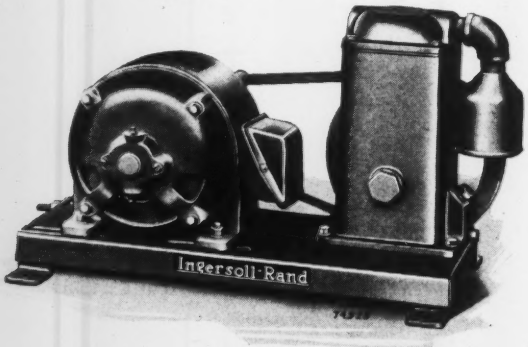


Model N machines available through 1 hp.



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60 Gotham PC's at Botany

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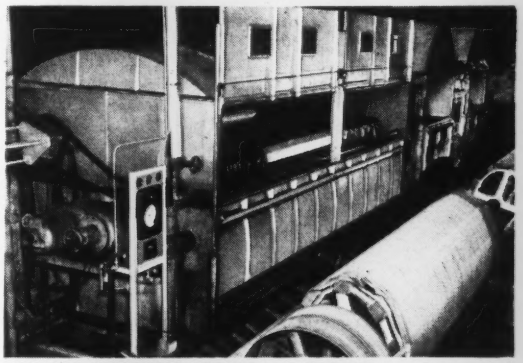
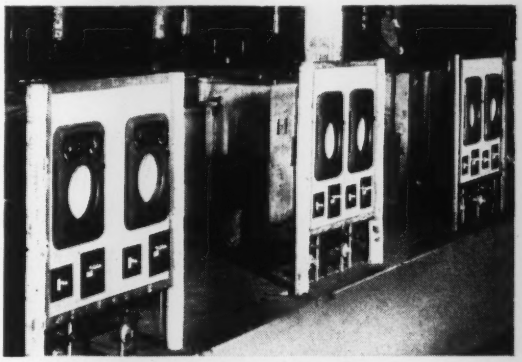
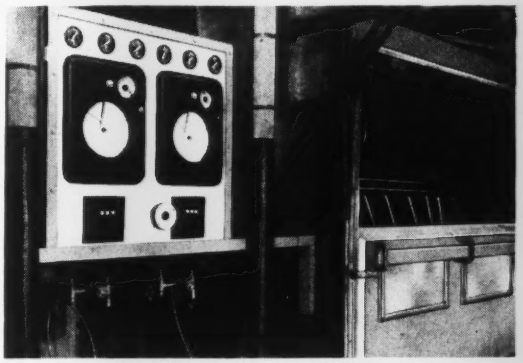


ONE OF WORLD'S LARGEST DYE KETTLES is at Botany and its dyeing cycle is supervised by Gotham Program Controller. Program control helps to maintain uniformity of the color.



12 TOP DYE KETTLE program controller units by Gotham are installed at Botany. Program control enables Botany to adjust quickly the variable time cycles required to get level dyeing.



EACH OF 48 DYE KETTLES like this at Botany, used for piece goods, is individually handled by its own Gotham Program Controller.

Photos: courtesy of Botany Mills, Inc.

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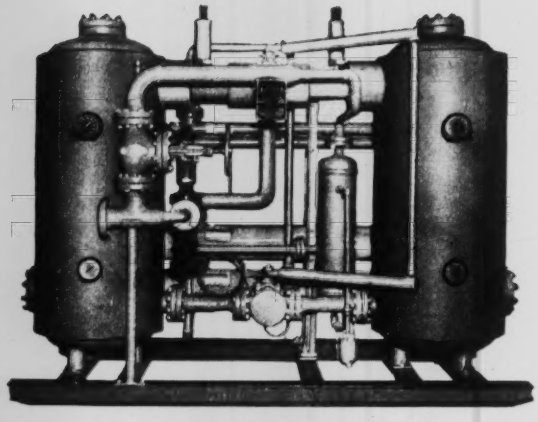

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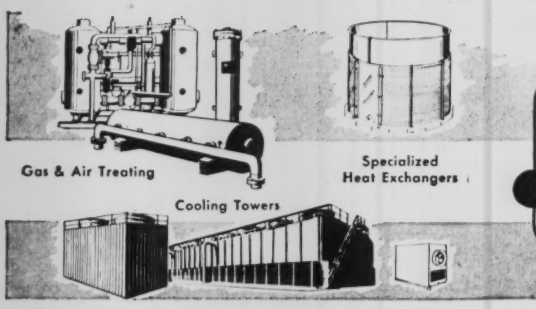

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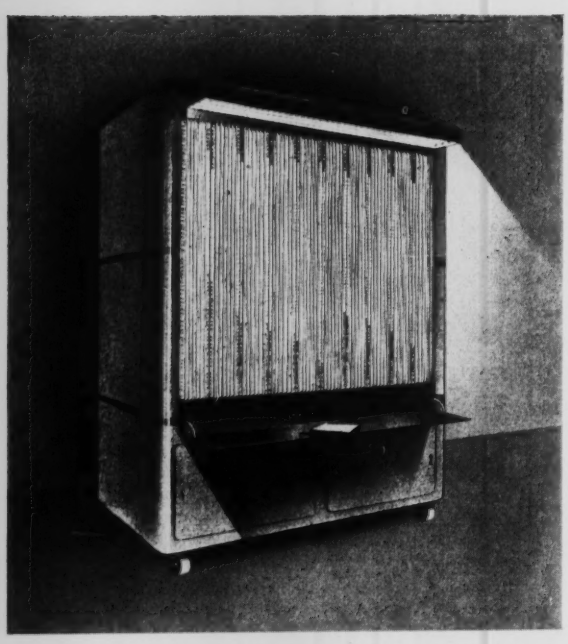

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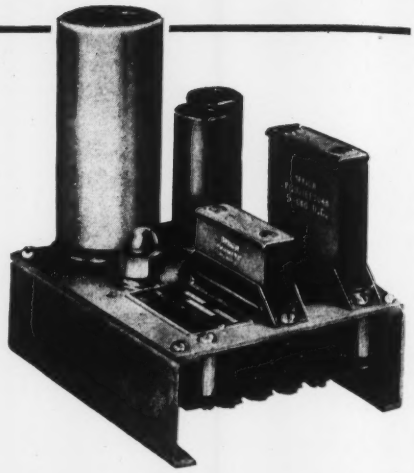

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Can a source of such frequency solve your design problem or increase its factor of safety?

Have you a system that requires great accuracy, stability and dependability?

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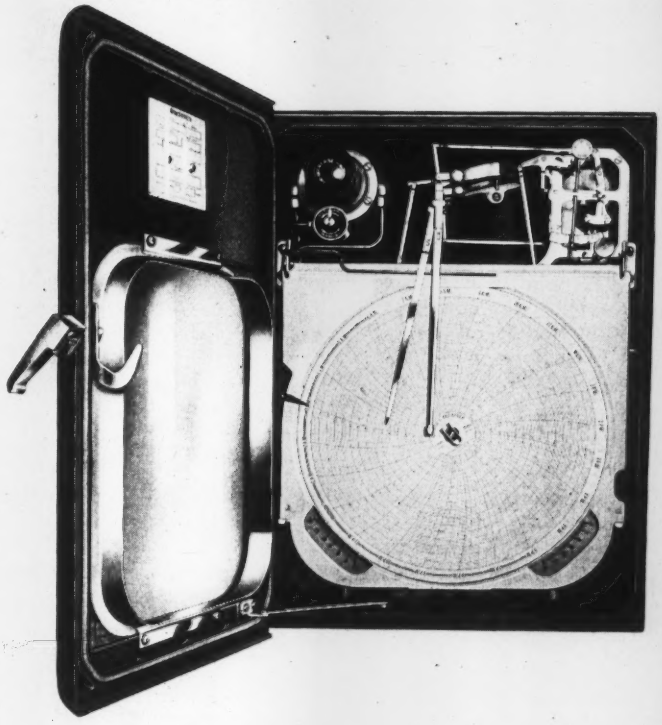
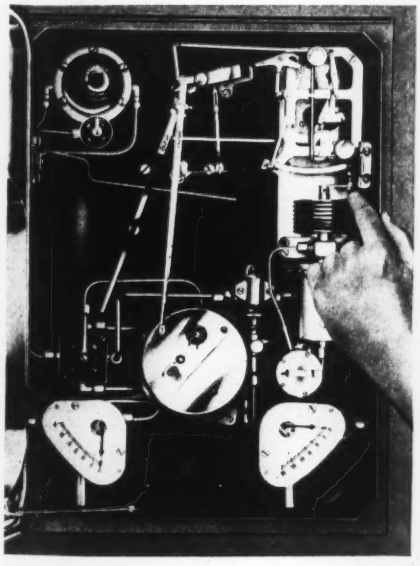


Plant operating men quickly become familiar with it . . . and like to use it



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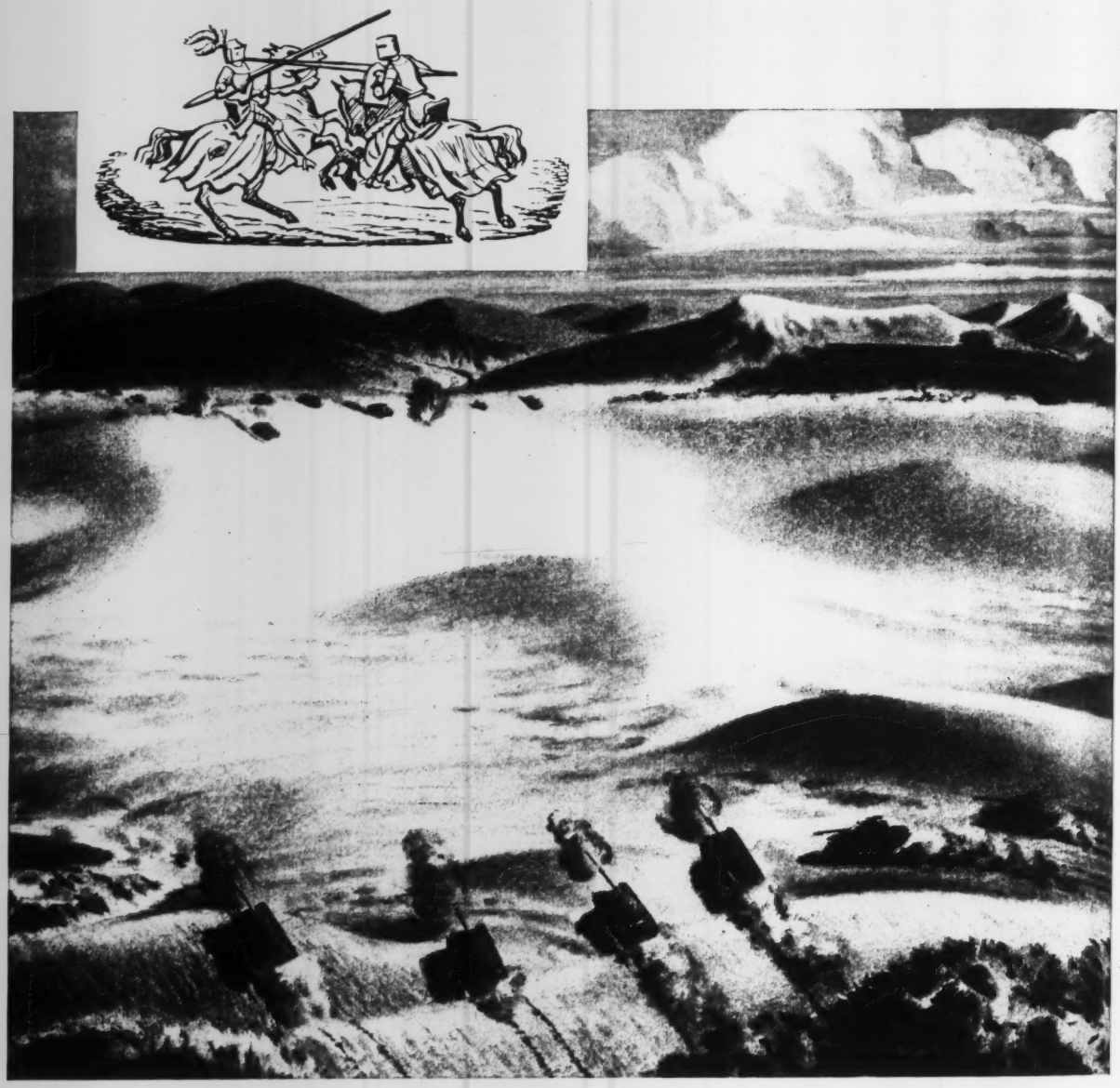

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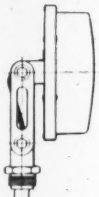
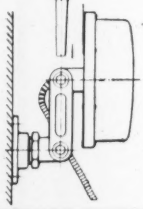


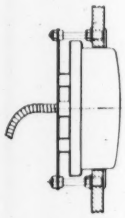
1 Rigid Stem Dial Thermometer

Rigid stem tapered bulb, interchangeable with standard industrial thermometer separable socket.



2 Wall Mounted Dial Thermometer

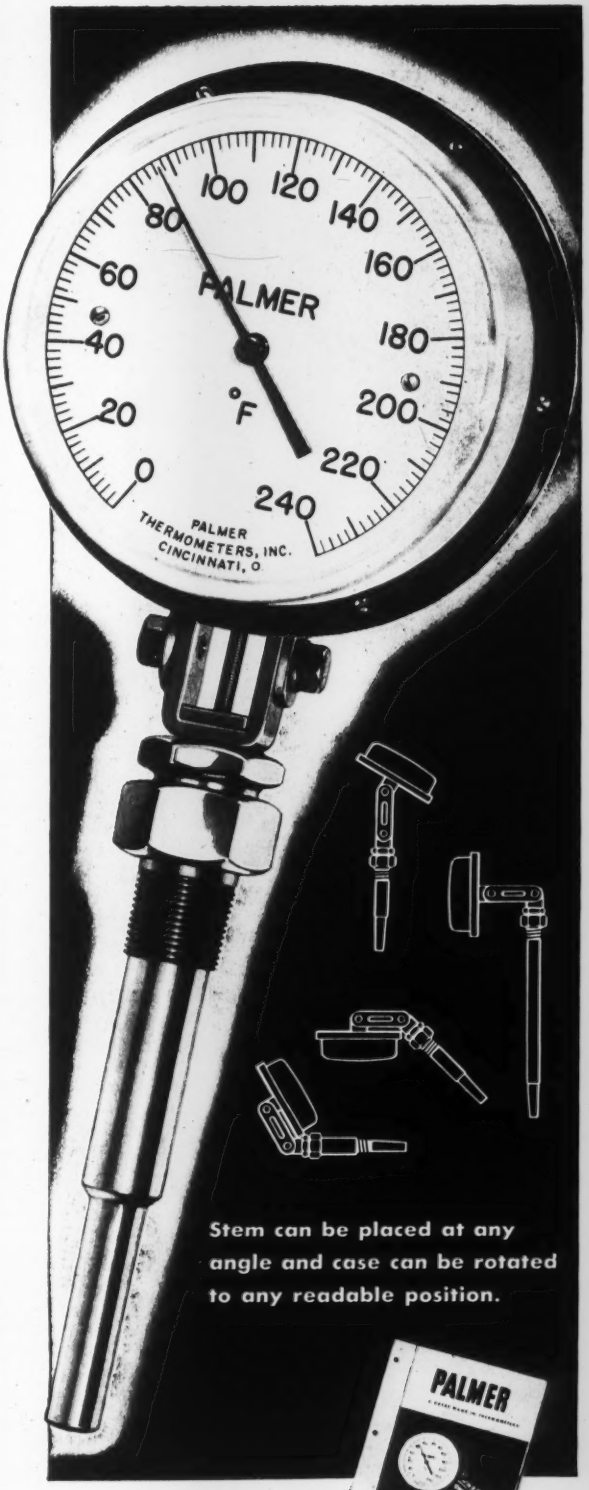
Wall mounted dial thermometer with flexible connecting armor. Case adjustable to easy reading position.



3 Flush Mounted Dial Thermometer

Flush mounted style for panel mounting with flexible connecting armor.

All three types have a full 4½" dial Face



Stem can be placed at any angle and case can be rotated to any readable position.

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for interchangeability: Always specify "PALMER" Separable sockets as they are interchangeable for Dial or Industrial type Thermometers.

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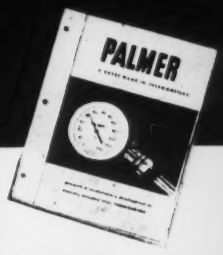

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RANGE — is continuously adjustable from a minimum of —0.1 to +1 mv . . . up to a maximum of —2 to +20 mv.

ZERO SUPPRESSION — uncalibrated coarse and fine . . . is continuously adjustable from —50 to +50 mv.

range and zero suppression are continuously adjustable

Just turn a knob . . . twist a dial . . . and you have adjusted this new Speedomax Recorder to the exact specs required for the automatic data-charting job at hand.

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Instruments THE MAGAZINE OF Measurement and Control

M. F. BEHAR, Editor

The First Symposium *on* Standardization *of* Thermocouple Wire Specifications*

ON June 19, 1951, a symposium was held in the Institute of the Aeronautical Sciences Building, Los Angeles, under the sponsorship of the IAeS-ASME Joint Aviation Instruments Committee. D. K. Warner of the Committee served as Chairman of the meeting and the Discussion Panel included R. L. Fine of the Air Matériel Command, Wright Field; H. D. Alexander of the Lewis Engineering Corp., Naugatuck, Conn.; P. A. Dennis, Chief of Engineering Lab, Douglas Aircraft Corp., El Segundo, Calif.; T. L. McNeely, Flight Test Engineer, North American Aviation, Los Angeles, Calif.; Burnie M. Craig, Consulting Engineer (Joint Committee); Lyell Collins, representing the Lewis Engineering Co.; and M. D. Pugh, representing *Instruments* Magazine and the ISA.

In addition to the above men who served on the Discussion Panel, representatives of the Scientific Apparatus Makers Association, the National Bureau of Standards, the Bureau of Aeronautics (USN) and the Leeds & Northrup Co. had been invited to sit in on the Discussion Panel but were unable to attend.

Also present at the Symposium were representatives from various aircraft manufacturers, equipment manufacturers, temperature instrument manufacturers, and the Engineering Department of the University of California at Los Angeles.

*Chairman's Report.

Calibration Standards for Iron-Constantan Thermocouples

In his introductory remarks Mr. Warner pointed out that there are two basic standards for the calibration of iron-constantan thermocouple wire in current use; one is usually referred to as the L&N 1913 calibration, the second is the calibration in accordance with NBS *Research Paper RP*-1080. It was pointed out that industrial and process equipment users, for the most part, have standardized on equipment calibrated to the L&N 1913 tables, whereas the Military Services and some of the aircraft manufacturers have standardized on equipment calibrated to the *RP*-1080 tables. Based on a request by the SAMA, the NBS recently undertook an investigation to evolve a new set of calibration tables for iron-constantan thermocouples which would more nearly represent the calibration actually obtained from wire which is generally available at this time. Based upon the outcome of this investigation, the NBS is proposing that a new standard should be adopted for thermocouple wire which would supersede and replace the L&N 1913 calibration. This new standard is tentatively referred to by the NBS as calibration curve A1, and the possibility was also introduced for consideration that this new standard would also replace the NBS calibration in accordance with *RP*-1080.

CHAIRMAN WARNER

Mr. Fine stated that he believed that the L&N standard wire represented at least 75 percent of all industrial use; however, Mr. Fine did state that the proposed A1 curve would not be suitable for the Armed Services and he doubted that it would be generally acceptable because too many re-calibrations would be required. He further stated that, as far as Military aircraft production was concerned, iron-constantan wire is being used less and less, and is now used for cylinder-head temperature measurement.

Mr. Pugh expressed the opinion that industry would have no serious objection to using wire calibrated in accordance with the proposed A1 calibration rather than continuing to use wire calibrated in accordance with the L&N 1913 tables. He noted that the difference in the calibration between the two was only a maximum of about 1 F. in the temperature ranges up to 1400 F. and that iron-constantan was seldom used at temperatures in excess of 1500 F. He concluded his preliminary remarks by stating that he wished to go on record as favoring the change to the proposed A1 curve.

According to Mr. Alexander, his Company's activities are strongly committed to the use of RP-1080 standards, and he felt that, owing to the present availability of metals, it would be wise to stick to RP-1080. Mr. Fine remarked that thermocouple wire in accordance with the L&N 1913 tables required

Continued on page 957

EDITORIAL COMMENT

IN January 1950 and again in January 1951, this page was devoted to the need of standardizing thermocouple calibration curves. Each time, the Guest Editorial was from the National Bureau of Standards and only slightly revised or abridged for publication here. Each time, it was *Instruments'* purpose to arouse interest among its subscribers—in industry, in the Armed Forces, in education, in societies—who constitute a representative and hence influential body of men as regards final acceptance of new standards. We wanted action; and we believed that we didn't have to write individual letters, for we knew that among our subscribers there are a number of "self-starters" with qualities of leadership. We had in mind such men as our good friend DeVer K. Warner of North American Aviation, whom many readers remember as the author of that splendid article on the XB-45 in the April 1949 issue. Sure enough, "Deke" (as they affectionately call him in aviation circles) was stirred to action. The Symposium here reported is a milestone. Read this report carefully; re-read the Jan. '50 and '51 Guest Editorials; and get your company (or institution or society) to take a stand. Now's the time for action.—MFB.

Radiation Pyrometers Control New High-gradient Heating Process

By H. W. COX, General Foreman, Power and Electrical Department, National Tube Company, Gary, Indiana.

ABSTRACT.—The temperature-control system for the high-speed high-gradient line of thirteen furnaces at the Gary plant of National Tube Company is described. The basic principles of high-gradient heating are outlined briefly. Photoelectric cells actuate the control system as the tubes pass through the furnace. A tachometer generator records line speed.

HIGH-GRADIENT heating, a comparatively recent introduction to the steel industry, has brought with it the need for a temperature-sensing device of rapid response. The radiation pyrometer has proved its value in solving this problem.

At the Gary plant of National Tube Company, where seamless tubes of a large variety of sizes and alloy compositions are made, reheating the tubes to the proper temperature required for final sizing is one of several critical processes in manufacturing a product of the highest quality. Contrasted to the former conventional low-temperature, long-time-batch or multiple-reheating methods, is the new continuous high-temperature, fast-speed line of thirteen furnaces. The line is shown in Fig. 1. A tube entering this line of furnaces after passing through the piercing and reeling operations requires, on the average, only 0.487 minute to attain the desired sizing temperature at the exit end.

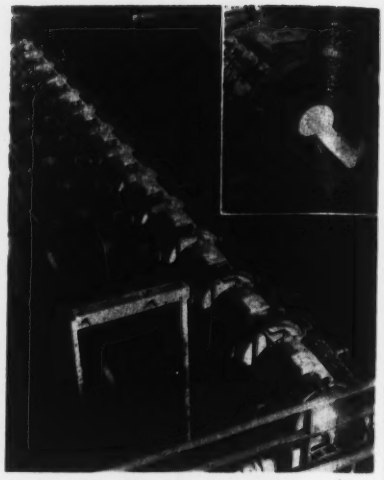

Fig. 1. High-temperature fast-speed line of furnaces.

Basic Principle of High-Gradient Heating

Furnace and burner design, plus a unique system of air-gas compression and carburetion, provide *accelerated combustion*. In this type of furnace, more fuel is burned in a given space than in the conventional reheating furnace, resulting in higher furnace working-temperatures. As metal heating is principally a function of time and temperature, it is obvious that a higher working temperature greatly reduces the time required for materials to remain in the furnace. In addition to high speed and time-saving uniformity of heating, less handling, less scale-formation, and lower fuel-consumption are claimed for this method of heating.

Tube-Temperature Control.—There is a radiation detecting element located at the entrance end of each of the thirteen furnaces. These elements sight on the moving tube as it enters the furnace. The fuel supply to the furnace is adjusted by a recording electronic potentiometer-type pneumatic controller, to which the radiation detectors are connected.

The control system is illustrated schematically in Fig. 2, which shows the basic instrumentation for all furnaces. Note that radiation detectors *R* are electrically connected to potentiometer-controllers *TRC* for each furnace. The controllers throttle diaphragm-motor valves *V* in the premixed air-gas supply manifolds. Experience has indicated that a narrow proportional band (2 percent) is satisfactory for this application, which has a high supply capacity and comparatively small load changes. The controllers, which are calibrated from 800 to 1900 F., are equipped with control bypass panels for manual control.

As tubes move through the 73 feet of furnaces at a rate of about 150 feet per minute, any given increment of tube is in each furnace for only about 0.037 minute. It is only because of the extremely rapid response of the radiation detector, plus the fast reaction of the furnace temperature to a change in fuel supply, that effective automatic control can be maintained. Under good average conditions, the tubes leave the final furnace at a temperature within plus or minus 20 F. of the set point.

The radiation detector comprises chromel-constantan thermocouples connected in series to form a thermopile. Radiant energy is focused onto the thermopile by means of lenses built in the detecting device. These detectors incorporate fittings for air cooling.

Temperature gradient set manually.—The set point of each of the tube-temperature controlling instruments is adjusted manually for each size and type of tube being run. Large, heavy-wall tubes require more heat than lighter stock and, consequently, the furnace temperatures are set higher for such runs.

It has been found most practical to set all furnaces for the same tube temperature, because the tubes make their own gradient as they pass from furnace to furnace. If the instrument set-points are properly adjusted, the tubes emerge from the last furnace in the line at exactly the desired temperature required for sizing. Tube-temperature set-points range from 1650 to 1800 F.

Photoelectric cells actuate tube-temperature control system.—As shown in Fig. 3. photoelectric cells *P*-1 and *P*-2 are installed at the entrance ends to the furnaces. All thirteen furnaces are equipped in this manner. A light source is so located under the path taken by the tubes when passing between furnaces that the light beam to the photoelectric cell is broken when a tube passes. When no tube is passing, the light beam is unbroken. The photoelec-

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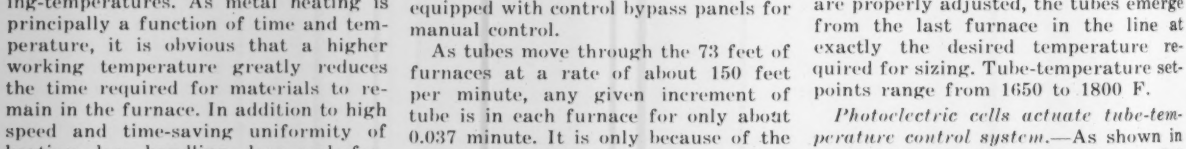


Fig. 2. Instrumentation of the line of reheating furnaces.

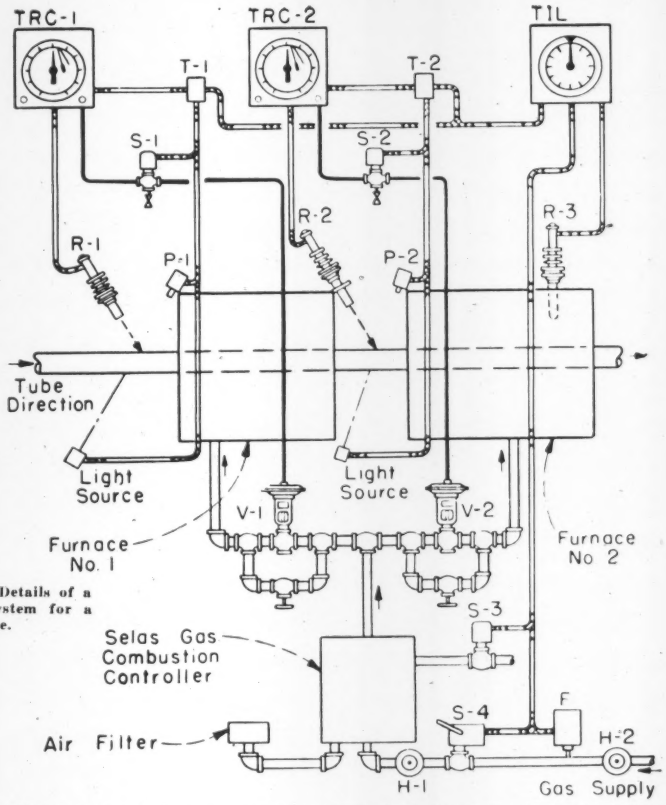


Fig. 3. Details of a control system for a given zone.

tric cell then actuates three-way solenoid valves *S*-1 and *S*-2 through time-delay relay *T*, automatically cutting back the furnace to minimum fire by bleeding air from diaphragm-motor valves *V*-1 and *V*-2 in the premixed air-gas manifold line. A bypass line, with a manually-operated valve, is installed around each diaphragm-motor valve to permit minimum fire to be maintained when the diaphragm-motor valve is closed. At the same time, the instrument balancing motor is de-energized. The electronic power pack in the instrument, however, remains energized.

In this manner, the recording pen remains at or near the tube temperature and the instrument is ready to assume control the instant the reverse action takes place—that is, when the light beam is broken again. Otherwise, despite the fast response of the detector and instrument, an undesirable instant would be required to bring the pen to the new tube temperature.

Furnace High-limit Temperature Control

To afford maximum protection to the tubes as well as to the furnace proper, a system of automatic high-limit furnace temperature control is provided. The line of thirteen furnaces is divided into six zones insofar as this protection is concerned. As shown in Fig. 2, the first five zones each comprise a pair of furnaces. The sixth zone comprises the last three furnaces—that is, numbers 11, 12, and 13.

Note that radiation detectors *R* are located in furnaces 2, 4, 6, 8, 10, and 12 for the respective zones 1 through 6. Although only one furnace in a given zone is used as the criterion of temperature measurement for that zone, the instrument controls all furnaces in a particular zone.

Three-contact controllers used.—Details of the high-limit control system can be observed by referring to Fig. 3, which shows zone number 1. Radiation detector *R*-3 sights into an air-cooled silicon-carbide target tube, which is mounted through the furnace wall. This detector is connected to a circular-scale indicating electronic-potentiometer (TIL), which is calibrated from 1200 to 2900 F. This instrument is equipped with three adjustable electric contacts to provide the following control action:

Should the temperature at which the first contact is set be exceeded, three-way solenoid valves *S*-1 and *S*-2 are de-energized, causing the furnaces to be put on minimum fire. Should the temperature continue to rise, causing the second contact to be made, solenoid valve *S*-3 is energized, permitting air to bleed into the combustion controller and leaning the gas-air mixture. Finally, should the temperature still continue to rise, the third contact opens, solenoid valve *S*-4 is de-energized, and the supply of gas is cut off entirely.

The temperature high-limit set points are fixed manually at the start of a run and, as with the tube-temperature controllers, vary with the type of material being processed. Normally the high-limit temperatures are within 2400 to 2600 F.

In the temperature high-limit controllers, the instrument scale rotates so that the measured temperature always is indicated at the top (12 o'clock position) by a large, black, triangular index. This arrangement makes for maximum convenience to the operator, who can check in a quick glance the temperatures prevailing in each zone.

Supply gas-pressure switch *F'* acts only when the pressure on the supply line falls below a minimum setting. When this occurs, the gas supply line is automatically closed by safety shut-off valve *S*-4. This solenoid valve also closes upon power failure.

Records of Gas Flow

For accounting purposes, as well as to afford a convenient check to the operator regarding proper gas-flow, a recording-integrating flowmeter is used in the installation.

As shown in Fig. 2, one main gas-line supplies the installation. Separate orifice runs are provided for natural gas and coke-oven gas. The two electric flow-transmitters *M*, for measuring the flow in either line, can alternately be connected to the receiver-recorder located on the main instrument panel through selector switch *S*.

Control of Line Speed

As shown in Fig. 1, an electronic recording-tachometer *SR* continuously charts the speed at which tubes pass through the line of furnaces. A tachometer generator, *T*, is connected to the roller conveyor line at the discharge end of No. 12 furnace. This information is valuable to the operator and also to the quality-control department.

Each conveyor roll is individually driven by a variable-speed motor. Power for these rolls is furnished by the motor-generator set located in front of the master control-panel.

The line speed normally is set manually by means of a single rheostat-control. An automatic speed-control system is incorporated for use, however, when alloy and stainless-steel specialties are being processed. This system functions as follows:

(1) Tube enters furnace at rate of 240 feet per minute until rear end of tube passes photoelectric cell at entrance end.

(2) Speed of furnace conveyors is decreased to a preset low rate as determined by heating requirements.

(3) Lead end of tube emerges from furnace No. 13, breaking light beam to photoelectric cell. This action causes conveyor speed to increase, ejecting tube from furnace to sizing mill.

Final Tube-temperature Record

As illustrated in Fig. 2, single-point strip-chart recording-potentiometer *TR* continuously logs the final temperatures of the tubes as they emerge from the line of furnaces.

Performance Analysis *of* Butterfly Valves*

By SYLVA DUSHKES COHN**

DATA ON butterfly valves obtained by different experimenters are correlated in terms of coefficients of flow (C_Q), thrust (C_S), and torque (C_T). The coefficients are derived in terms of both static pressure differential and total pressure differential, including velocity head. Two classes of operation are considered: (1) where delivery is limited by a downstream pressure greater than atmosphere, and (2) where downstream pressure is atmospheric or less and where, therefore, delivery depends only on the opening of the valve. All in all, this is the most informative *single* article on butterfly valves published in the last decade.—ED.

INTRODUCTION

INFORMATION for the design of butterfly valves is difficult to obtain because of the small number of publications on the subject. The problem of obtaining a sufficient amount of information for design purposes from the work already done in the field is made even more difficult by the lack of uniformity of approach to the subject among the published works. Thus, it is difficult to compare validly the work of various observers in the field.

It is the object of this article to analyze and to correlate the results obtained by different experimenters, and in so doing, to point out where their assumptions and their experimental set-ups differ. Also, possible lines of approach for further investigation are suggested.

PROBLEM

Stated generally, the problem is this: Given a butterfly valve of diameter D in a line, it is desired to find the flow, Q, through the valve; the torque, T; and the thrust, S, on the valve, as functions of the pressure differential and of the position of the butterfly.

It is necessary first to consider the relationship and nature of the factors involved. The flow, Q, is proportional to the velocity of the fluid, and to the area through which the fluid is flowing. The velocity is a function of the pressure differential across the valve. The first factor to be considered, then, is the pressure differential. The pressure to be used in calculating the characteristic coefficients of the butterfly can be the static drop taken across the valve, ΔP, or it can be the drop measured so as to include the upstream velocity head. This drop is termed $\Delta P'$ (Fig. 1).

Moreover, it is not merely the difference between the upstream and downstream pressures which determines the performance of the valve, but the specific values of these pressures as well. For example, distinction may be made between two classes of valve operation on the basis of the downstream pressure.

The first class of valve operation includes those valves whose delivery is limited by a downstream pressure which is greater than atmospheric. This counterpressure may be established, for example, by a reduced outlet orifice, or

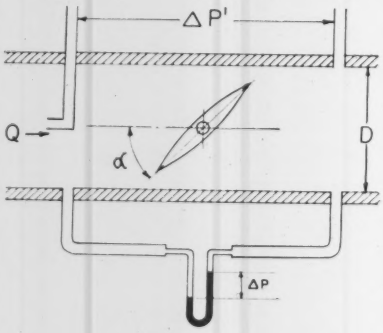


Fig. 1

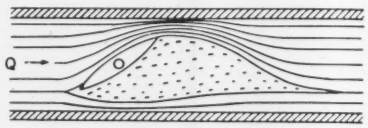
a positive discharge head, or simply a straight run of pipe extending several diameters downstream of the valve.

The second class of valves includes those whose delivery under a given upstream pressure depends only on the degree of opening of the butterfly, because there is negligible variation in the downstream pressure. In this case, the downstream pressure is equal to or slightly less than atmospheric. Such a valve delivers to a divergent nozzle, or to a nozzle which opens to atmosphere immediately after the valve.

The second factor to be considered is the apparent free area presented the fluid. If the fluid approaches and passes through the valve opening with the lines of flow continuing parallel to the pipe axis, the free area presented the fluid is the cross-sectional area of the line less the area of the valve projected on it. The flow pattern, however, is as shown in Fig. 2. The lines of flow are not much disturbed on the lower side of the valve, but on the upper side they are deviated along the valve face. Behind the valve there is a core of fluid in which the flow is turbulent. As the cross-sectional area of the core decreases, partial recovery of the kinetic energy of the fluid takes place. Usually, in an analysis of butterfly valves, the area is taken as that of the pipe line, and the velocity, V, is defined such that the product of the area and this velocity gives the measured value of the flow, Q.

The third factor in determining the flow is the density of the flowing fluid.

It is desired then to determine a coefficient of flow that will characterize the valve under consideration. If a dimensional analysis is made, the flow, Q, can be related to the variables which determine it—valve diameter, pressure differential, and density of the flowing fluid—to give a dimensionless ratio. This ratio, which is then a function of



BASED ON DIAGRAM FROM D. GADEN, "CONTRIBUTION À L'ÉTUDE DES VANNES PAPILLONS"

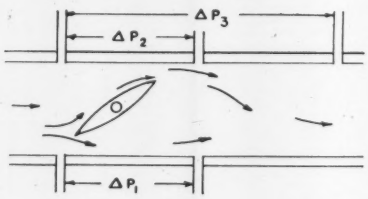


Fig. 2

the valve position, is the characteristic coefficient of flow that is discussed in this article.

The thrust and the torque that the valve experiences are functions of the pressure differential across the valve, the area of the valve, and its position. However, the thrust and torque are independent of the density of the flowing fluid. The ratio of thrust and torque to the valve diameter and the pressure differential yields dimensionless coefficients that are functions of valve position, and these coefficients also are considered in this article.

TEST CONDITIONS

In correlating and evaluating various data, one must keep in mind possible variations of test conditions which can cause variations in the results obtained.

A major source of variation lies in the measurement of the pressure. One point that cannot be overemphasized is the importance of where the pressure measurements are made. The pressure drop measured immediately before and after the valve, ΔP_2 of Fig. 2, can be greater than that measured with the downstream tap removed from the valve by a distance of several diameters, due to the partial recovery of the kinetic energy of the fluid. This second pres-

*Presented at 1946 Annual Meeting of the American Society of Mechanical Engineers; not published by the ASME.

**The author was with Askania Regulator Co. at the time of presentation; she is now with Special Operations Division, U. S. Naval Radiological Defense Laboratory, San Francisco, Calif.

sure differential is designated ΔP_3 in Fig. 2. Even taps placed the same distance from the valve, as measured from the valve center along the pipe axis, can give different readings depending on whether they are above or below the valve, because the taps can pick up small impact pressures when the flow is not parallel to the pipe axis. Thus ΔP_1 may differ from ΔP_2 in Fig. 2. Unfortunately, data on butterfly valves do not usually include the necessary information as to where the pressures are measured, so that it is not possible to evaluate this factor when comparing data from various sources.

The flow around the valve is influenced, of course, by the shape of the valve. As can be seen in Fig. 3, which shows cross-sectional views of the valves that are considered in this report, valves differ in shape, thickness, and symmetry. They may be thin plates whose ratio of thickness to diameter, d/D, is as small as 1 percent, or they may be lens-shaped valves with maximum value of the ratio of valve thickness to diameter as high as 25 percent. They may be unsymmetrical in shape. They may close at an angle of 90 degrees, or they may have a smaller closing angle. They even may be mounted eccentrically. Each of these differences is reflected in the characteristic coefficients of the valve. For this reason, experimental data should include a specification of the size and shape of the valve. Of course, it is further necessary to know the manner in which the flow coefficient varies as a function of the various shape factors, such as the ratio of valve thickness to valve diameter. It is just this type of information, however, that is lacking, and this makes it difficult to correlate results from various sources. Experimental investigation should be made showing variation of the coefficients as functions of various dimensionless shape factors.

Another factor influencing the pattern of flow around the valve is the way in which the fluid approaches the valve. Test conditions should be such that the length of the line on the upstream side of the valve is sufficient to insure straight-line flow to the valve.

As was mentioned previously, conditions downstream of the valve are equally important in establishing the performance characteristics. When it is a question of delivery with positive downstream counterpressure, the length of the line downstream of the valve should be sufficient to insure recovery of the kinetic energy of the fluid.

Another source of variation in the values obtained for the characteristic coefficients is the fluid used for the tests. Under certain conditions, for example, the flow of air gives coefficients that cannot be applied when flow of water is to be considered. In one of the papers which considers tests made with air, the authors, Drs. C. Keller and F. Salzmann[3], state that the results obtained from tests made with air can be applied to the flow of water if care is taken in the tests to keep the velocity of the air well below the velocity of sound. This is to insure that the effect of the compressibility of air is negligible. Especially with valves that deliver immediately to atmosphere, the nature of the flowing medium is of great importance. One can see that valves which discharge to atmosphere may have different characteristics for air flow than for water flow.

Also, as Keller and Salzmann point out, under certain operating conditions, as for example, liquids flowing at high velocity, or those near the boiling point, the vapor pressure is reached at certain points on the valve surface. At these

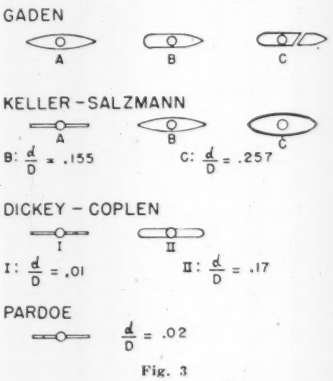


Fig. 3

points cavitation occurs. Air tests do not reveal this. Thus, cavitation sets a lower limit to the pressure on the rear of the valve for water flow, whereas the corresponding lower limit of the pressure for air flow is not thus restricted.

Some of the tests were made with small valves; others were made with large valves. Results obtained from tests made on small valves can be applied to large valves, and vice versa, when the two arrangements are geometrically similar.

All of the factors discussed should be specified for a test so that a complete and valid comparison with the results of tests of other experimenters can be obtained, and further, so that it will be known under what conditions the results apply.

Equations for Flow

The flow in a pipe line is equal to the product of the area of the pipe line and the velocity of the fluid flowing in the line.

$$Q = A\ V, \tag{1}$$

where

Q = Rate of flow.
A = Cross-sectional area of valve and pipe line.
V = Velocity of fluid in pipe line.
C = Coefficient of velocity.
C' = Coefficient of velocity.
ΔP = Pressure differential (static).
$\Delta P'$ = Pressure differential (including velocity head).
ρ = Density.
D = Diameter of valve and pipe line.

The velocity of the fluid can be expressed in terms of a coefficient of velocity, the pressure differential, and the density of the fluid. The coefficient of velocity is simply the ratio of the actual velocity to the ideal velocity.

$$V = C\sqrt{\frac{2\,\Delta P}{\rho}} \tag{2A}$$

$$V = C'\sqrt{\frac{2\,\Delta P'}{\rho}} \tag{2B}$$

The cross-sectional area of the pipe line can be expressed in terms of the line diameter:

$$A = \frac{\pi D^2}{4} \tag{3}$$

If the expressions for the velocity and the area as given in equations (2) and (3) are substituted into equation (1), equation (4) obtains:

$$Q = C\frac{\pi}{4}D^2\sqrt{\frac{2\,\Delta P}{\rho}} \tag{4A}$$

$$Q = C'\frac{\pi}{4}D^2\sqrt{\frac{2\,\Delta P'}{\rho}} \tag{4B}$$

If the coefficient of velocity is grouped together with the constants of the equation, we can call the group of terms C_Q. This is a dimensionless coefficient of flow.

$$C_Q = C\frac{\pi}{4}\sqrt{2} \tag{5A}$$

$$C_Q' = C'\frac{\pi}{4}\sqrt{2} \tag{5B}$$

The flow, Q, can be expressed in terms of the coefficient of flow, the valve diameter, the pressure differential, and the density of the flowing fluid:

$$Q = C_Q D^2\sqrt{\frac{\Delta P}{\rho}} \tag{6A}$$

$$Q = C_Q' D^2\sqrt{\frac{\Delta P'}{\rho}} \tag{6B}$$

The coefficient of flow is dimensionless, and therefore the variables D, ΔP (or $\Delta P'$), and ρ can be expressed in any system, provided that their units are consistent.

The equations have been derived for the static pressure drop, ΔP, and the total pressure drop, $\Delta P'$. The two coefficients of flow derived, C_Q and C_Q', are related as follows, in terms of the coefficients of velocity:

$$C_Q = \frac{C_Q'}{\sqrt{1-C'^2}} \tag{7A}$$

$$C_Q' = \frac{C_Q}{\sqrt{1+C^2}} \tag{7B}$$

Data: Flow Coefficient, First Class of Operation

Fig. 4 displays in graphical form the data on the flow coefficient for the first class of operation. C_Q is plotted as a function of α, the angle of closing of the valve.

It is of interest to consider the test set-ups as described in the published reports, to see how the tests differed

and why variations may be expected among the results.

Consider first the data presented by Keller and Salzmann[5]. The tests were made with air. The experimenters knew the limitations imposed on air tests, and made their tests accordingly. Pressure measurements were taken four diameters upstream and eight diameters downstream of the valve.

The Gaden report[4] gives data taken on three disks, which differed in shape and symmetry. The first was a lens-shaped valve, similar to one used by Keller and Salzmann. The second was unsymmetrical, with one end lens-shaped, and the other end simply rounded. The third valve also was unsymmetrical, with a fixed stop in the line (Fig. 3). The tests were made with water. The closing angles for the three Gaden valves are smaller than those of the other valves considered. They lie between 70 and 80 degrees.

Data are presented also on tests made by W. S. Pardoe[6]. The valve used was a thin plate (Fig. 3). The test was made with water.

Two curves were taken from data given in a paper by P. S. Dickey and H. L. Coplen[2], which was presented to the ASME in 1941. The tests were made with air flow. Data are presented in this comparison on two butterflies whose shapes are most like those of other valves under consideration. The butterfly which is designated as Type I is a thin plate. The butterfly labelled Type II is a thicker, streamlined plate (Fig. 3).

The highest values of the flow coefficient were obtained from the streamlined valves: the Dickey and Coplen streamlined valve gave the highest values, with the lens-shaped disks of Gaden and of Keller and Salzmann giving values just below this. The thin plates of Dickey and Coplen and of Pardoe give the next lower set of values, and the lowest, as would be expected, were obtained with the unsymmetrical Gaden disk C.

It must be kept in mind that there are a number of factors operating at once, such as shape of the valve, relative thickness, and symmetry, each entering to a different degree.

The variation in the results between the Gaden disk A and the Gaden disk C is as great as, or is greater than, most of the variations among the data from different sources, indicating that the shape of the valve is of importance in determining the coefficient of flow.

It must also be remembered that the closing angles of the different valves varied, running from 70 to 80 degrees for the Gaden disks, to 90 degrees for the other valves, thus introducing another source of variation.

Besides differences in shape and closing angles of the valves, variations of the flow coefficient may be due to differences in measuring the pressures. Not all of the sources, however, describe their test set-ups in detail, so that a comparison cannot be made on this basis at present.

Equations for Thrust and Torque

S = Thrust.
K = Coefficient of thrust.
K' = Coefficient of thrust.
A = Cross-sectional area of valve and pipe line.
ΔP = Pressure differential (static).
$\Delta P'$ = Pressure differential (total).
D = Diameter of valve.

The thrust is equal to the product of a coefficient of thrust, the area of the valve, and the pressure differential:

(8A) $$S = K A \Delta P$$

(8B) $$S = K' A \Delta P'$$

If the area is expressed in terms of pipe diameter, equation (9) is obtained:

(9A) $$S = K \frac{\pi}{4} D^2 \Delta P$$

(9B) $$S = K' \frac{\pi}{4} D^2 \Delta P'$$

If the coefficient of thrust is combined with the constants of the equation, a coefficient of thrust, C_S, is defined:

(10A) $$C_S = K \frac{\pi}{4}$$

(10B) $$C_S' = K' \frac{\pi}{4}$$

The thrust can be expressed in terms of a coefficient of thrust, the diameter, and the pressure differential:

(11A) $$S = C_S D^2 \Delta P$$

(11B) $$S = C_S' D^2 \Delta P'$$

The coefficients of thrust, C_S and C_S', are related as follows:

(12A) $$C_S = \frac{C_S'}{1 - C'^2}$$

(12B) $$C_S' = \frac{C_S}{1 + C'^2}$$

Similarly, the torque, T, is proportional to a coefficient of torque, the cube of the valve diameter, and the pressure differential:

(13A) $$T = C_T D^3 \Delta P$$

(13B) $$T = C_T' D^3 \Delta P'$$

The coefficients of torque are related as follows:

(14A) $$C_T = \frac{C_T'}{1 - C'^2}$$

(14B) $$C_T' = \frac{C_T}{1 + C'^2}$$

Data: Thrust and Torque Coefficients, First Class of Operation

Only two sources gave data on thrust. The data are shown in Fig. 5. There is good agreement between the sources. Both the coefficients C_S and C_S' are plotted. The Gaden data were given only for values of α equal to and greater than 15 degrees.

The data for Gaden disks A and B were computed on the basis of an approximation. The Gaden equation for thrust includes a variable pressure correction term which is combined with the pressure differential. For disk C this term was zero. The approximation is made that it is zero for the other two disks as well. This approximation is satisfactory as the correction is quite small.

From the Gaden data it appears that the maximum value of the thrust depends on the shape of the valve. Only one curve is presented by Keller and Salzmann, so that there is no further information on this point. The Keller and Salzmann data check very well with the Gaden data for disk A, which was most like the Keller and Salzmann valve.

Fig. 6 shows data from three sources on the torque coefficient for the first

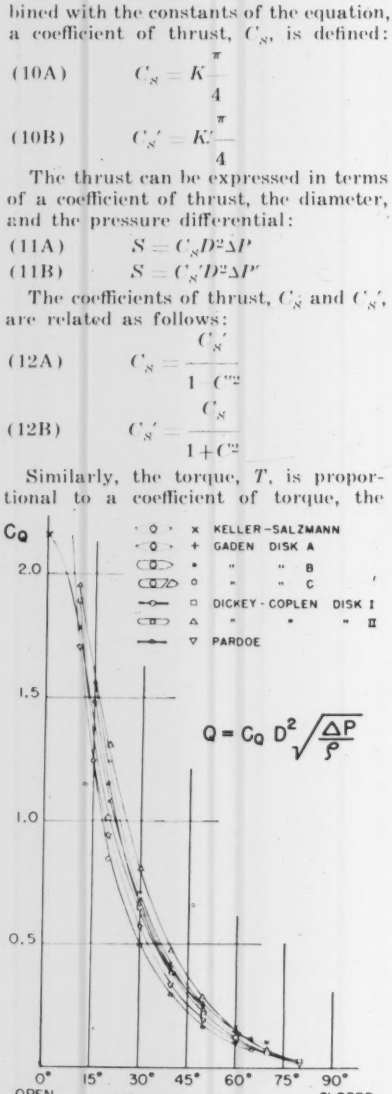


Fig. 4. Coefficient of flow, C_Q, vs. closing angle, α

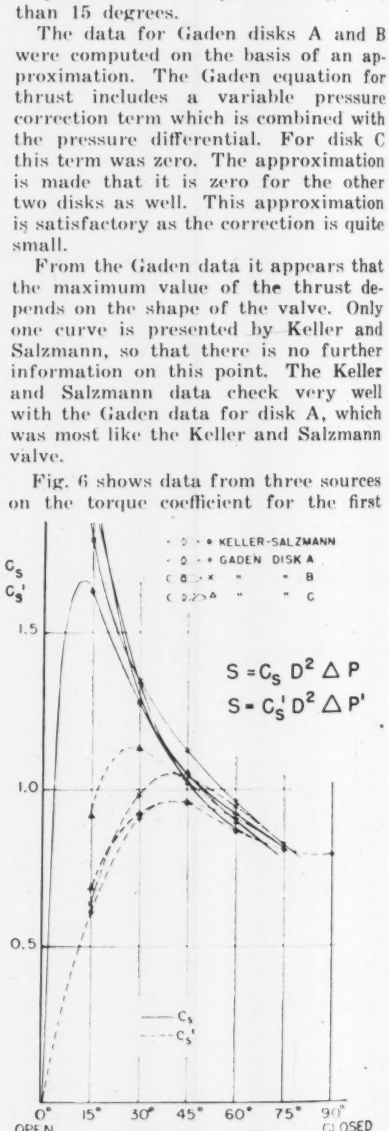


Fig. 5. Coefficients of thrust, C_S, C_S' vs. closing angle, α

class of operation. Gaden presented data on torque for three disks. Curve B of the Gaden data was computed on the basis of the approximation mentioned for thrust. The pressure-correction term had to be neglected in order to make a comparison with the other data. For disks A and C this term was zero.

The Keller and Salzmann tests were made on three valves which differed in relative thickness. Disk A was a thin plate, and disks B and C were lens-shaped valves, with C having a greater relative thickness (Fig. 3). Also, tests on disks A and B were made with air, and on disk C with water. As can be seen, several variable factors are operating simultaneously, so that it is difficult to judge what the effect of one of them—for example, shape—has on the maximum point of the curve. In general, however, it appears from the Keller and Salzmann data that the relative thickness of the valves has little influence on the maximum value of the torque, but determines the position of the butterfly at which the maximum is attained.

From the three Gaden curves it appears that the maximum value of the torque depends on the shape and symmetry of the valve, but that the angle at which this value is attained is little influenced by the valve shape. On this point Gaden[4], who compared his results with those of Keller and Salzmann, remarks in his paper that: "from the point of view of maximum value of the torque, the discrepancies, although obvious, are not too great . . ."

As the variation among the three Gaden valves is not the same as the variation among the three Keller and Salzmann valves, no definite conclusion can be drawn on this point from the data available.

Fig. 6 shows also a curve taken from Wunsch, as reported in *Regler fur Druck und Menge*.[8] The values of the Keller and Salzmann data for torque are higher than those based on Wunsch data by a maximum of about 100 percent. However, it is not possible to trace the discrepancy, inasmuch as Wunsch does not give a specification of his test conditions.

Data: Flow Coefficient, Second Class of Operation

For the second class of valve operation—those valves which deliver with a downstream counterpressure that is equal to or less than atmospheric—the quantity of data is smaller, and the terms used to describe the performance vary even more widely than for the first class.

Data for the flow coefficient for the second class of operation are shown in Fig. 7. The pressure differential used is $\Delta P'$. The coefficient, therefore, is C_Q' of equation (6B), but is designated as C_Q'' to indicate that it is used for the second class of operation.

Gaden data are shown for disks A and B. Gaden also considered in his paper the results of tests made by E. A. Dow[3], published in a report by the National Electric Light Association. Dow presented data on the velocity of the flowing medium for a valve operating with water flow. From the figures presented, the flow and flow coefficient were computed by Gaden. It is seen that the Gaden results for the flow coefficient correlate very well with those of Dow for values of α greater than 12 degrees.

A graph from E. X. Schmidt[7] gives data on a coefficient taken for the flow of air for the second class of operation. It was expected that the flow of air for the second class of valve operation would give results different from those obtained from tests made with the flow of water. This is seen in the curves shown in Fig. 7. The coefficient of flow based on the Schmidt data for tests made with air vary from the data taken by Gaden and Dow in water tests, for angles of closing under 30 degrees. For values of α greater than 30 degrees the agreement is good.

Fig. 7 presents also data taken on the flow of air from the results of tests made by G. A. Davis[1]. The flow coefficient computed from the data checks the data of Schmidt very closely.

Data: Torque Coefficient, Second Class of Operation

The torque coefficient for the second class of operation are shown in Fig. 8. The data are taken from the Gaden paper, which compares the results taken on disks A and B with the results of Dow. It is seen that the values for the torque coefficient based on data taken by Dow are higher than those of Gaden up to values of α equal to 25 degrees, but that the difference between the Gaden curve for disk A and that for disk B is as great as that between the Gaden A curve and the Dow curve.

The pressure differential used in obtaining the torque coefficient for the second class of operation is $\Delta P'$, and the coefficient, therefore, is C_T'. It is referred to in Fig. 8 as C_T'' to indicate the second class of operation.

Summary

The problem of obtaining butterfly characteristics is divided clearly into establishing data for two separate cases.

It was found that for the case of positive downstream counterpressure, fairly good correlation is obtained in the values of the characteristic coefficients of butterfly valves when the data are reduced to the same terms. The correlation for flow is the best, and the

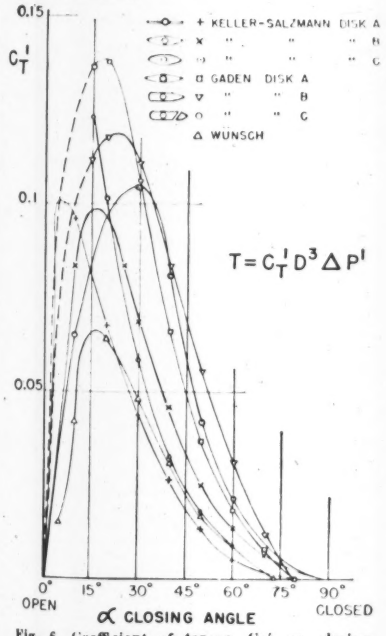


Fig. 6. Coefficient of torque, C_T', vs. closing angle, α

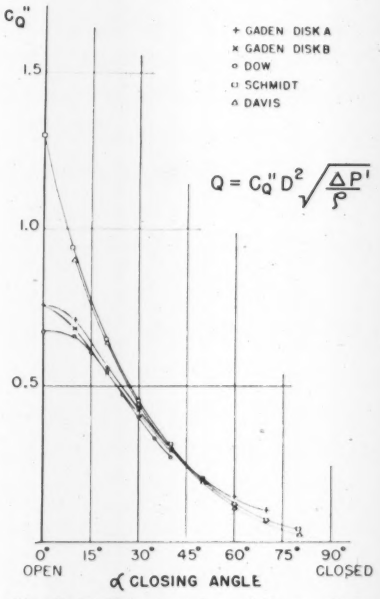


Fig. 7. Coefficient of flow, C_Q'', vs. closing angle, α

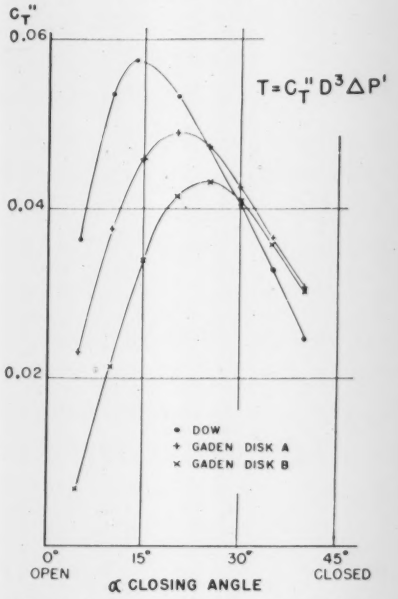


Fig. 8. Coefficient of torque, C_T'', vs. closing angle, α

results have been applied successfully to design problems, by choosing data for valves of the proper shape.

For torque, the correlation is not as good, but the latitude can be tolerated because valves are designed with a large safety factor.

In future tests more information should be given concerning test conditions. The test set-up should be described in detail, with information given on the shape of the valve, the fluid used, and how pressure measurements were made. An investigation of the effect of shape factors on flow and torque should be made.

It is suggested that further investigation be made along the lines of a dimensional analysis. When such an analysis is made on the valve, it is found that the performance can be characterized in terms of a few dimensionless ratios—the coefficients presented in this paper, which are functions of the valve position, and shape factors. In such an investigation it is necessary that all the variables except one be held constant in a test. Such a systematic investigation will be the most rewarding, as the role of each variable will be shown clearly. In this manner, the performance of a valve in a given system may be made to check design values closely, and developments which might improve the value can be seen more easily.

Grateful acknowledgement is made to the following persons who assisted in the preparation of this article:

Mr. H. Ziebolz, of the Askania Regulator Co., who collected material and offered valuable suggestions in the preparation of the paper; Mr. Paul Wing, of the Mason-Neilon Regulator Co., who called attention to and provided a copy of the Gaden report; Mr. G. Ziegler, of the Taylor Instrument Co., who suggested the method of approach; Mr. G. A. Davis, of the Wilputte Coke Co., and Mr. E. X. Schmidt of the Cutler-Hammer Co., who supplied data on the results of their tests on butterfly valves.

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Design *of an* Unattended Automatic Booster Station

By J. P. HEDLIN, Products Pipe Line Department, Standard Oil Co., Chicago

Two 125-hp. pumps are controlled by an automatic pressure-operated system. Three Mercoid pressure switches, a delay timer, and an incomplete-sequence relay provide safety features.

STANDARD Oil Company (Indiana) recently supervised the construction of an unattended automatic booster station on Wyco's products pipe line from Casper, Wyoming, to Denver, Colorado. This accomplishment is a pioneer effort and may be a first in the industry. As this station has been in operation only since July 1950, no overall operating and maintenance experience is available to date; however, the station was given a rigorous series of trial runs and it functioned as designed.

Building Cost

The station is a small station of only 250 hp. It was found that the total cost of the station was no greater and possibly less than the cost of a similar attended station. These savings were realized because of economies in building, heating plant, and foundations, which offset the added expenditures for the necessary automatic equipment. Only a simple prefabricated steel structure is required.

As the station is unattended, no heating plant, water well, and other facilities are required. The station has the advantage over a conventional station of realizing savings of approximately $20,000 to $25,000 per year in operating labor.

Presented at the April Meeting of the Chicago Section, ISA, April 9, 1951, Chicago, Ill.

Equipment

The primary considerations in the design of an unattended automatic booster station are the pumping equipment and the controlling devices. The pumps must operate without danger of a leak in the event of a gland (or seal) failure. The pump that meets this requirement is the stuffing-box-less type. As the motor and pump are completely enclosed in a pressure-tight bolted case, the stuffing box and packing are eliminated. This does away with a principal cause for maintenance.

One of the salient features in this type pump is the mechanical seal between motor and pump. The motor, including its bearings, operates completely submerged in an enclosed pressure chamber filled with transformer oil, which is used for the dual purpose of insulation and lubrication. Leakage across the mechanical seal is regulated so that it occurs only from the motor side to the pump side, thus preventing any product from leaking into the motor casing. This is accomplished by keeping the transformer oil at a higher pressure than the product pressure when the pump is in operation. While the unit is shut down, the pressures in the pump case and the motor case are equal and the spring tension on the mechanical seal prevents leaking from the pump side to the motor side. To protect the pumps, a pump diaphragm switch is installed in each pump to shut down the unit automatically when the reserve supply of insulating and cooling oil approaches depletion.

To date, these pumps have been manufactured in only 125-hp. size, which has limited the size of fully automatic stations. One prominent pump manufacturer has indicated a willingness to manufacture this type pump up to 400-hp. size. The reluctance of manufacturers to produce this pump in large sizes is based on the difficulty of cooling the motor. Until a reasonable demand is created for stuffing-box-less pumps in sizes over 125 hp., the price will be high.

The unattended automatic booster station is a two-unit, 250-hp. station capable of pumping 18,500 bbl./day of 0.73 specific-gravity gasoline at a pressure of 215 psi. per unit, or a total of 430 psi. for both units. The station was named Bear Creek and its location is shown in Fig. 1. This station has a control system for completely automatic operation of the pumps in accordance with the setting of a master control switch, which can be set for either one unit, two units, or no units operating—depending on desired line throughput. It is essentially a pressure-controlled station and pumps as long as the upstream station supplies sufficient pressure.

Fig. 2 shows the profile for the Wyco Line. Normally the profile is not important in the operation of a pumping station; however, for the Bear Creek Station, the profile is important. Note that the static head on Bear Creek Station is 500 psi. (gasoline). As one unit of

this station can develop a shutdown head of only 315 psi. (gasoline), some provision must be made to prevent the pumps from spinning and overheating. This problem was solved by installing a mercury pressure switch on the discharge side of the station. This pressure switch opens at 530 psi. and closes at 700 psi. This means that when the discharge pressure (with the station operating) drops to 530 psi., the switch opens and shuts down the station. The station remains inoperative until the pressure supplied by the upstream station rises to 700 psi., at which time the switch closes and places the station in operation.

Station Piping

Fig. 3 shows the station piping. Note that the pumps are installed in such a manner that when not in operation, flow is directed through the pump sump and the check-valve bypass. The divider gates are in the main line, which necessitates shutting down the station and opening these gate valves whenever scrapers are run. However, runs are so infrequent that this procedure imposes no serious problem. The strainer shown is a coarse mesh of four openings per inch.

Note that two Mercoids are installed on the discharge side of the station. The control Mercoid prevents the discharge pressure from falling below hill pressure when one unit is operating. The one labeled "high-pressure Mercoid" is installed to shut down the station when the discharge pressure exceeds the maximum allowable operating line-pressure—1200 psi. This Mercoid is set to trip at 1220 psi.

Operation

The low-pressure Mercoid on the suction side of the station is set to open at 200 psi. and to close at 700 psi. When two units are operating and the upstream station is shut down, the suction Mercoid opens to shut down Bear Creek Station. When one unit is operating and the upstream station is shut down, the minimum discharge pressure is reached before the suction pressure reaches its minimum. Therefore, the control Mercoid stops the station. Reset of the low-pressure and control Mercoids is set at 700 psi. This means that the upstream station must supply 200 psi. more than the static condition to put Bear Creek Station on the line. All three of these controls are electrically connected in series, which requires all of them to be in closed position for the station to operate.

When the station is set for operation and sufficient pressure is present to close the control Mercoid and the low-pressure Mercoid, the first unit starts. Simultaneously with the starting of the pump, the motor-operated discharge valve begins to open. This valve takes 45 seconds to reach full-open position. As it approaches full-open position, the bypass check-valve is closed by the differential pressure created by the pump. As a safety feature, a delay timer shuts down the unit if the motor-operated valve fails to open. When a unit stops, the control wiring is arranged so that the motor-operated valves close. However, in the event of a power failure, the motor-operated valve remains open until power is restored. As the discharge valve remains open, flow is directed automatically through the pump sump and check valve as in Fig. 3.

As an added safety feature, each unit has an incomplete-sequence relay installed in its control wiring. This relay prevents the pump from attempting to start again if it fails to complete its starting cycle for any reason. For instance, if the motor-operated valve fails to reach its full-open position in one and a quarter minutes, the unit stops and the valve closes. The incomplete-sequence relay prevents the unit from attempting to start again until manually reset.

Each pump unit has under-voltage time-delay relays that prevent the unit from being shut down due to momentary voltage dips. This relay trips two seconds after voltage failure. A voltage dip causes the motor starter to drop out and stop the motor, but if voltage is restored within two seconds, it starts again without going through a complete shutdown and starting sequence. If the second pump is to be used, it starts ten minutes after the first pump starts and in the same sequence. This delay between the starting of units allows the first unit ample time to load up and accelerate the stream. The pumps are started across the line with 440-volt oil-immersed combination starters with solenoid-operated contactors. Each motor-feed circuit is connected to an open reverse-phase relay which trips when the power supply reverses phase or has one of its phases open. The action of either relay shuts down both units.

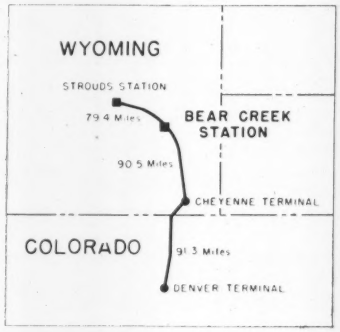


Fig. 1. Location of booster station on pipe line.

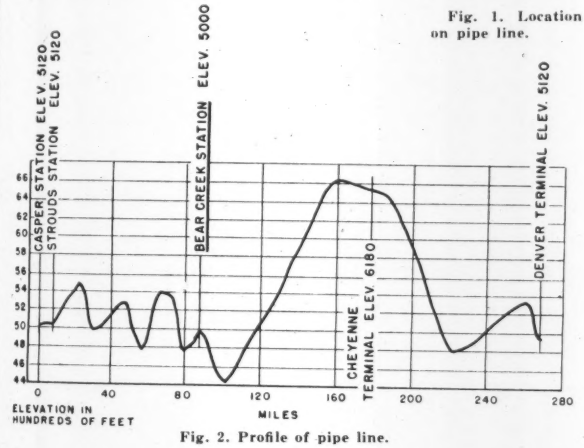


Fig. 2. Profile of pipe line.

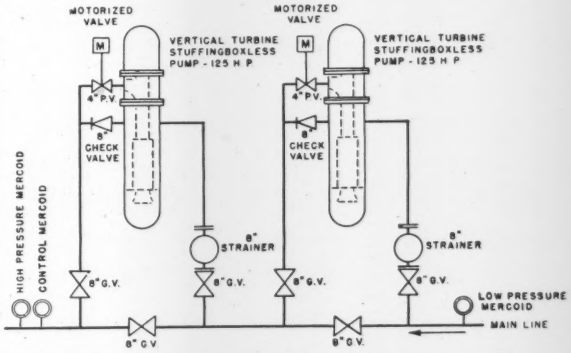


Fig. 3. Station piping.

To assist operating personnel, a series of graphs were constructed. These graphs relate the discharge pressure at the origin station (Strouds) to the volume pumped by the station. The curves show the extremes and the average for the terminal receipts. The value of the curves to the operator lies in the fact that for any given pumping rate, number of units operating at Bear Creek, and terminal delivery, he can quickly determine his discharge pressure at the origin station. From the dispatcher's point of view, these graphs are invaluable in that for any required pumping rate and terminal delivery, he can predetermine and preset the number of units to be operated at Bear Creek during any month for a given tender of products.

The design has provided additional capacity at a remote location and to date has proven entirely satisfactory. This installation may be the prototype for similar improved pumping stations that will operate without personnel on duty. The significance of this cannot be ignored in view of increasing operating costs.

Survey *of* Industrial Instruments Courses *in* Engineering Schools

By MALCOLM B. HALL, Director of Training and
KENNETH A. BELL, Associate Director of Training
The Foxboro Company, Foxboro, Mass.

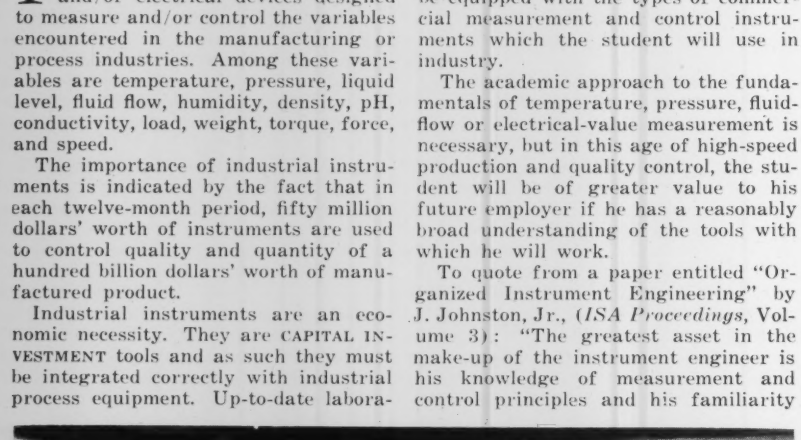
INDUSTRIAL instruments may be defined as commercial mechanical and/or electrical devices designed to measure and/or control the variables encountered in the manufacturing or process industries. Among these variables are temperature, pressure, liquid level, fluid flow, humidity, density, pH, conductivity, load, weight, torque, force, and speed.

The importance of industrial instruments is indicated by the fact that in each twelve-month period, fifty million dollars' worth of instruments are used to control quality and quantity of a hundred billion dollars' worth of manufactured product.

Industrial instruments are an economic necessity. They are CAPITAL INVESTMENT tools and as such they must be integrated correctly with industrial process equipment. Up-to-date laboratories in engineering schools contain unit operations apparatus that should be equipped with the types of commercial measurement and control instruments which the student will use in industry.

The academic approach to the fundamentals of temperature, pressure, fluid-flow or electrical-value measurement is necessary, but in this age of high-speed production and quality control, the student will be of greater value to his future employer if he has a reasonably broad understanding of the tools with which he will work.

To quote from a paper entitled "Organized Instrument Engineering" by J. Johnston, Jr., (*ISA Proceedings*, Volume 3): "The greatest asset in the make-up of the instrument engineer is his knowledge of measurement and control principles and his familiarity with the equipment and its applicability."



Illustrations from Professor J. B. Gray's article on course at Syracuse University in June 1950 *Instruments*, pages 557-559.

What Schools Are Doing

A questionnaire was mailed on August 15, 1949, to 136 schools with engineering curricula accredited by ECPD in their report for the year ending September 30, 1948. To date, 115 replies have been received and tabulation of the data follows. The figures are the numerical total of answers.

Questions listed:

1. Do you teach "Industrial Instruments" at the undergraduate level? Yes, 80; No, 32; 13 graduate courses.

2. Is "Industrial Instruments" taught and listed in your catalog as a separate subject? Yes, 47; No, 65.

3. In what department is the subject covered? Chem. Eng., 51; Elect. Eng., 39; Mech. Eng., 43; Civil Eng., 16; Ind. Eng., 6; Petr. Eng., 3; Others, 18.

4. Elective, 28; Required, 38; Freshman, 4; Sophomore, 9; Junior, 22; Senior, 38.

5. Semester hours for "Industrial Instruments": Lecture (46) Min. 1, Max. 4; Laboratory (31) Min. 1, Max. 6; Preparation (24) Min. 2, Max. 10.

6. Teaching Material: Instrument Manufacturers' Catalogs, instruction sheets, slides or models, 62, texts by Rhodes, 22; N. Y. State Vocational, 11; D. P. Eckman, 22; others, 16.

7. Laboratory equipment: Unit operation equipment, with instruments, 49; process analogs with instruments, 11.

8. Instrument-company personnel as guest lecturers? Yes, 31; No, 53.

9. Have instructors on your faculty attended instrument manufacturers' training schools? Yes, 14; No, 83.

10. Would you be interested in a 3-week summer course for your instructors at an engineering school or at the Foxboro Training School? Engineering School, 16; Foxboro School, 13; Either, 33; Either possibly, 9; No, 16.

11. Do you propose to establish a course in "Industrial Instruments?" Yes, 18; No, 37; ?-13.

General use was made of the space provided under REMARKS, for explanations and amplifications; several questionnaires were accompanied by letters.

Analysis of Returns

Analysis of the returns, including remarks, indicates:

a. Lack of understanding of what is meant by "Industrial Instruments."

b. Wide differences of opinion regarding the courses in which this subject should be taught. (Question 3).

c. Differences of opinion regarding the importance of the subject. (Questions 4 and 5).

d. Desire for better preparation by instructors. (Questions 9 and 10).

e. Lack of appreciation of the importance of the subject. (Question 11).

What Schools Can Do

No implication is intended here that undergraduate courses in Industrial Instrumentation should attempt to qualify students as instrument engineers. The student's interest may lead him to pursue the subject further in a graduate course in which he may explore the theory of process control. The object of a well-designed basic course is to enable the student to acquire a practical knowledge of commercial industrial instruments with which he will be able to develop new processes and improve present processes for greater efficiency.

The confusion apparent by the answers to Questions 3 and 4 rationalizes conclusions a, b and c. A basic course should be available to students in Chemical (including Petrochemical) and Mechanical Engineering at least.

From the standpoint of process operation, the chemical engineer finds a field of activity in the greatest number of industries, and industrial instruments are essential for process operation. *If there is any question regarding the course in which this subject should be introduced, chemical engineering should have first consideration.* It is an interesting observation that the instrument companies employ as sales engineers more men with a chemical engineering background than with any other type background.

It is desirable that mechanical, electrical, and engineering students of physics have a knowledge of industrial instruments because there is a large field of activity in tne design and fabrication of process operation equipment. Designs are influenced by the potential application of instruments for measurement and control. The field of activity for such men with instrument knowledge in the research or development phase of the instrument industry is quite limited. The instrument-user industries offer the greatest opportunities for engineers with instrument knowledge.

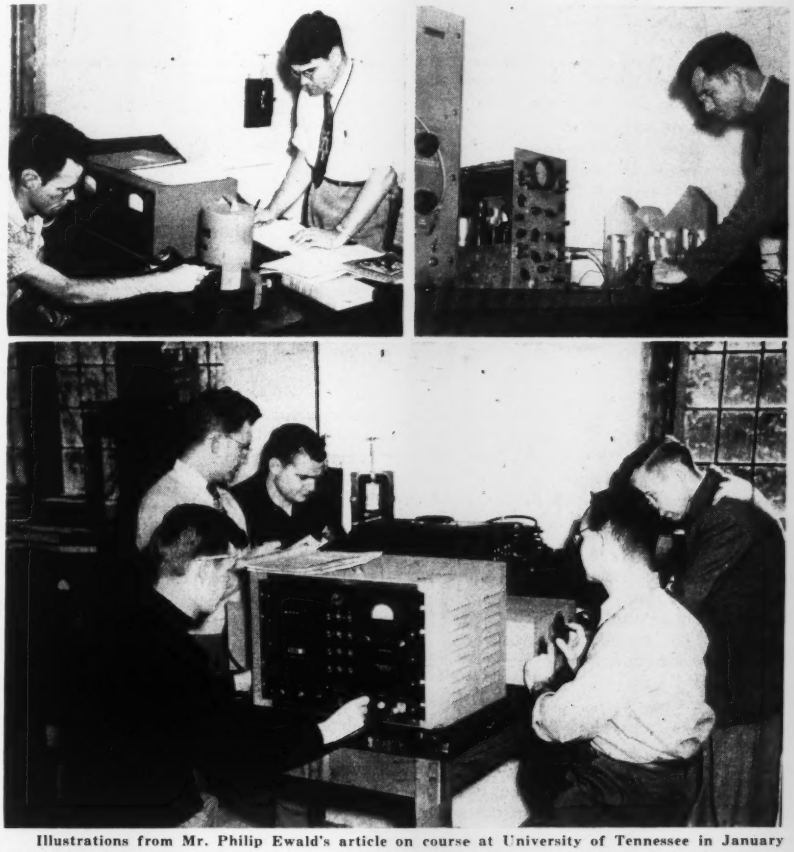
Objectively, therefore, an instrument course should be sufficiently broad to cover the field of industrial process measurement and control; should be available to students in any engineering course in which measurement and control problems are encountered; and should be required in those courses from which the greatest number of students will come in contact with process operations in industry.

A number of engineering schools are including measurement theory in several courses. This instruction can be more effective if the course of study requires student reference to instrument-company catalogs and engineering data. This will offer to the student at least a partial survey of the instruments used commercially for measurement and control.

It is hoped that the presentation of this report, with a philosophical discussion of the objectives, will foster a more universal course of study for Industrial Instruments.

Illustration from Professor M. H. LaJoy's article on course at University of Minnesota in April 1951 *Instruments*, pages 406-407.

"An instrument course should be sufficiently broad to cover the field of industrial process measurement and control; should be available to students in any engineering course in which measurement and control problems are encountered; and should be required in those courses from which the greatest number of students will come in contact with process operations in industry."



Illustrations from Mr. Philip Ewald's article on course at University of Tennessee in January 1950 *Instruments*, pages 34-35.

INSTRUMENT ELECTRONICS

By M. H. ARONSON, Managing Editor, *Instruments*

II. CIRCUIT ELEMENTS

Part 1—Resistors and Capacitors

The basic circuit elements are resistance, capacitance, and inductance. The principles and uses of resistance and capacitance are discussed in this article. Vector notation of sine waves is described briefly.

IT HAS been shown that (1) a current is the flow of electric charge—usually electrons, (2) the force, or pressure, that causes the current is called voltage, potential, or electromotive force (emf.), (3) a battery is a source of direct current (d.c.), and (4) a generator is a source of either direct current or alternating current (a.c.).

The Sine Wave

The most common type of alternating waveform is the *sinoidal* waveform, or *sine wave*, one cycle of which is shown at the bottom of Fig. 2-1. The time of one cycle is known as the *period* of one cycle. The frequency of the wave is the number of cycles per second.

A simple way of representing an alternating wave is by a rotating *vector*. A vector is a line used to denote the size and direction of a given quantity. For example, the sine wave of Fig. 2-1 can be represented by the arrow, or vector, which is shown at the left of the wave. If the vector rotates counterclockwise, the projection of the vector on the vertical at any instant is the amplitude of the sine wave at that instant. Thus the amplitude of the sine wave at any point on the cycle is defined completely by the vector, which rotates counterclockwise. The length of the vector defines the maximum amplitude of the sine wave, and the direction of the vector determines the amplitude at any instant.

Note that one cycle of the sine wave corresponds to one revolution of the vector. Therefore, the frequency of the wave corresponds to the angular velocity of the vector. The frequency of a sine wave (or the angular velocity of the equivalent rotating vector) sometimes is expressed in radians per second rather than in cycles per second. As 360 degrees equals 2π radians, you may see sine waves plotted against radians or degrees.

Phase

Fig. 2-2 shows two alternating currents which differ in phase. The term "phase" refers to the amount by which a varying magnitude has varied from its initial, or starting, value. In Fig. 2-2, wave A is leading wave B by ¼ cycle, or 90 degrees. That is, at any one time, the amplitude of A is ¼ cycle ahead of the amplitude of B. The two waves are said to be out of phase by 90 degrees.

Vectors are useful because a number of out-of-phase waveforms can be represented simply by straight lines. Vectors also simplify the addition of sine waves. As there always are out-of-phase currents and voltages in circuits which have capacitance and inductance, it is necessary to use vectors to represent the currents and voltages.

Rate of Change

An important fact about a sine wave is that the continuously changing wave changes most rapidly when it passes through zero amplitude. That is, the rate of change is maximum at zero amplitude. The rate of change of the wave is zero at the maximum amplitudes. This fact is important in the operation of inductors and transformers.

Circuits

A circuit is a closed path through which current can flow. The amount of current that flows through a circuit when a given potential is applied across the circuit depends on the character of the elements in the circuit.

There are three basic circuit elements—resistors, capacitors, and inductors. *Any device in an electric circuit can be analyzed and simulated by its effective resistance, capacitance, and inductance.* Therefore, it is essential that the student or worker in the field of electricity and electronics understand completely the principle and operation of these basic elements, of which all circuits consist.

Resistance

Resistance is the opposition to the flow of electrons. Materials with an abundance of free electrons, such as metals, have low resistance. This means that a low potential can cause a high current in a metal conductor. Silver, copper, aluminum, zinc, and iron are good conductors.

Air has few free electrons. It resists the flow of electrons. Materials with high resistance are called *insulators*, or *dielectrics*. Dry air, glass, porcelain, rubber, bakelite, and mica are good insulators.

A *resistor* is a circuit element designed to introduce a desired amount of resistance into a circuit. Resistors can be fixed, adjustable, or variable. Fig. 2-3 shows typical fixed resistors. The top four resistors are carbon composition resistors. The fifth resistor is a wire-wound power resistor. The symbol for fixed resistors is shown also. The bands on the fixed composition resistors are a color code, which is described later.

Fig. 2-4 shows an adjustable resistor (top), and two variable resistors. Note that the resistors have connections to both ends and to the movable tap. Although the variable resistor with the easily movable tap is commonly called a potentiometer, this term is reserved in instrument work for a device that measures potential. Hence, the variable resistor with the easily movable tap is called a *voltage-dividing resistor* (VDR) in instrument work. The adjustable resistor sometimes is called a *rheostat*.

Types

Manufacturers offer a wide variety of resistors, depending on size, power rating, tolerance, temperature coefficient, and reliability under various operating conditions. The two

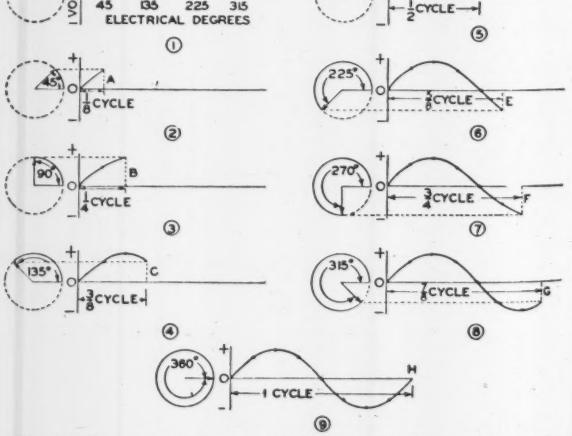


Fig. 2-1. Development of one cycle of a sine wave by a rotating vector.

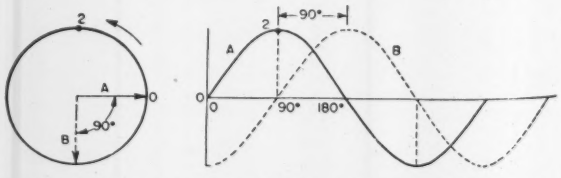


Fig. 2-2. Two sine waves with phase difference of 90 degrees.

most common types are carbon composition and wire wound. Other types are woven wire, deposited carbon, and metal film.

Instrument circuits require high-quality resistors which retain their resistance for their lifetime, and which do not change value excessively for extreme conditions of temperature, humidity, vibration, etc. Composition resistors, which are cheap and widely used, do not have as good stability characteristics as wire-wound resistors. However, wire-wound resistors are larger and more expensive. Most power resistors designed to carry large currents are wire wound. Composition, carbon-film, and metal-film resistors have better high-frequency characteristics than wire-wound resistors because of the inductance of the winding. However, some wire-wound resistors are made with noninductive windings. Carbon resistors generate more noise than wire-wound resistors.

Ohm's Law

A voltage (E) applied across a resistor (R) causes a current (I) to flow through the resistor. A simple relationship exists between E, I, and R. This relationship, known as Ohm's law, states that the current through a resistor (in amperes) equals the voltage applied across the resistor (in volts) divided by the resistance of the resistor (in ohms). That is:

$$I = E/R, \text{ or } E = IR, \text{ or } R = E/I.$$

Note that the unit of resistance is the *ohm*.

Phase

When a varying d-c. or an a-c. potential is applied across a resistor, the current follows any variation in the potential immediately. For example, if a 2-volt d-c. potential is applied across a 1-ohm resistor, the current is 2 amperes; if the potential varies from 2 volts to 1 volt periodically, the current changes from 2 amperes to 1 ampere. In other words, the resistance of a resistor is independent of frequency. This is not true for capacitors and inductors.

When the potential across a resistor varies, the current variations occur simultaneously with the potential variations. When the potential is a maximum, the current is a maximum. When the potential is a minimum, the current is a minimum. Therefore, the current through and the potential across a resistor are *in phase*, as shown by the two vectors in Fig. 2-5. The lengths of the vectors represent the maximum value of current (I) and voltage (E). The fact that the vectors are superimposed shows that the current and voltage are in phase—that is, both reach maximum and minimum values at the same time. This is not true for capacitors and inductors.

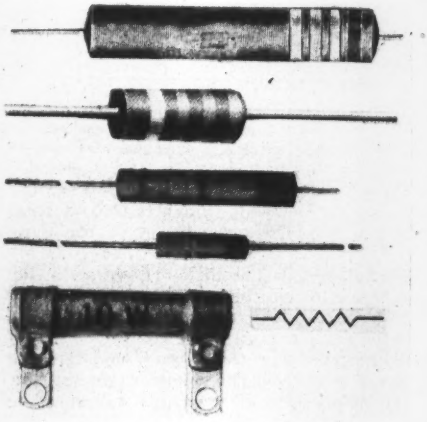


Fig. 2-3. Five fixed resistors and symbol.

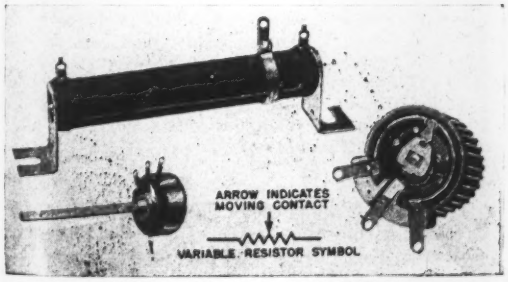


Fig. 2-4. Rheostat and two VDR's.

Power

Power is the rate at which work is done. In a hydraulic system, the power required to keep water flowing against a certain head is equal to the flow (pounds per minute) times the pressure, or head (feet). In electric circuits, the current is a flow (coulombs per second) and the voltage is a pressure which is equivalent to the head. Thus, power (W) is the product of amperes (I) and volts (E).

$$\text{Power} = \text{amperes} \times \text{volts}$$
$$W = E \times I = I^2R = E^2/R.$$

The product of amperes and volts in a resistive circuit is the power in *watts*.

When a current, I, flows through a resistor, R, a power of I^2R *watts* is dissipated as heat. Therefore, the resistor must be of proper size and heat-radiation construction to dissipate the power without excessive rise in temperature, which changes the resistance of the resistor if it does not destroy it. As shown in Fig. 2-5, power is dissipated on both half-cycles of an a-c. wave. This is because the product of a negative current and a negative voltage is a positive power.

All resistors are rated as to their power-handling capacity. In any application, it is essential that a resistor of proper rating be chosen. It is a safe practice to use a resistor whose power rating is twice the maximum power it is expected to dissipate.

Simple Resistive Circuits

There are two basic types of circuits—series and parallel. However, an infinite number of combinations of series-parallel arrangements is possible.

Fig. 2-6,A shows three resistors in series with a battery. Fig. 2-6,B shows three resistors in parallel with a battery. Fig. 2-6,C shows one resistor in parallel with three resistors in series. Fig. 2-6,D shows two resistors in series with two resistors in parallel.

Resistors in Series

The total resistance of a number of resistors in series equals the sum of the individual resistors. That is, the total resistance to flow of current in Fig. 2-6,A is

$$R = R_1 + R_2 + R_3.$$

Resistors in Parallel

The total resistance of a number of resistors in parallel can be found from the fact that the potential across each is

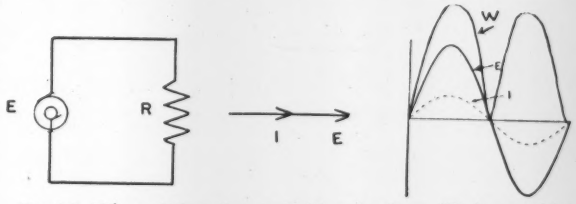


Fig. 2-5. Phase relation of current (I) and voltage (E) in a resistor, and power curve (W).

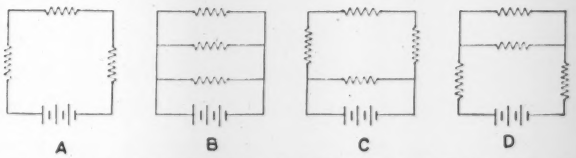


Fig. 2-6. Series-parallel arrangements of resistors. A, Series; B, parallel; C, one resistor in parallel with three series resistors; D, two resistors in series with two parallel resistors.

the same, and that the total current supplied by the source is the sum of currents in each branch. For example, if currents I_1, I_2, and I_3 flow in the three branches in Fig. 2-6,B, then:

$$I \text{ (total)} = I_1 + I_2 + I_3 = E/R_1 + E/R_2 + E/R_3.$$

If the total resistance of the three resistors is R, then:

$$I = E/R = E/R_1 + E/R_2 + E/R_3.$$

Therefore, the formula for resistors in parallel is:

$$1/R = 1/R_1 + 1/R_2 + 1/R_3 + \ldots$$

If R_1, R_2, and R_3 are each 1 ohm:

$$1/R = 1/1 + 1/1 + 1/1 = 3$$

$$R = 1/3 \text{ ohm.}$$

Note that the total resistance of resistors in parallel always is less than the smallest resistance. Just as several pipes in parallel offer less resistance to the flow of water, resistors in parallel offer less resistance to current than is offered by any one resistor in the circuit.

Use of Resistors

The primary use of resistors in circuits is to develop signal or operating voltages of a desired amplitude. The voltage developed across a resistor R by a current I is IR. Therefore, a signal voltage of IR volts can be obtained by sending a current I through the resistor. The voltage IR is called an *IR drop*. Resistors are used commonly as plate loads in vacuum tubes to develop IR signals.

Fig. 2-7 shows how two resistors provide different potentials, or IR drops. Note that the battery potential can be divided into any desired ratio by choice of suitable resistors. Resistors used this way are called *voltage dividers*.

Capacitance

A capacitor consists of two conductors, called *plates*, separated by an insulator, or *dielectric*. The dielectric can be air, mica, glass, wax paper, oil, or any nonconductor.

The series circuit in Fig. 2-8 consists of a capacitor, a switch, and a source of d-c. voltage. When the switch is in position 1, (Fig. 2-8,A), plates X and Y are at the same potential—that is, they contain equal numbers of positive and negative charges.

Charging

When the switch is in position 2 (Fig. 2-8,B), electrons on plate X are attracted to the positive terminal of the battery, thus leaving plate X charged positively—that is, with a shortage of electrons. The negative terminal of the battery supplies electrons to plate Y to give it a negative charge. As the electrons cannot flow through the capacitor because of the dielectric, the capacitor is now *charged*, and the plates are at different potentials.

No direct current can flow through the capacitor because of the dielectric. However, if a galvanometer is inserted in the circuit, the galvanometer needle deflects momentarily when the switch is moved from position 1 to position 2, showing that current flows for an instant. This current charges the capacitor to a potential equal to that of battery. When the voltage across the capacitor equals the battery voltage, current ceases and the capacitor is fully charged.

The positive and negative charges on the plates of the capacitor attract each other, but they cannot reach each other because of the dielectric. These charges set up an electric field between the plates. This electric field, shown by the lines between the plates, represents electric energy stored in the dielectric. If the switch is moved to position 3, the applied voltage is removed, but the electrons have no conducting path and the capacitor remains charged.

Discharging

If the switch is moved back to position 1, the galvanometer needle deflects momentarily, but in a direction opposite to its deflection when the capacitor was charging. The capacitor is now *discharging*. The excessive electrons on plate Y travel to plate X until the charges on the two plates are the same, at which time the current and the potential difference between the plates are zero.

If the galvanometer is placed between two capacitors, and if the experiment is repeated, it is found that when the switch is operated, the galvanometer deflects the same way as in Fig. 2-8—that is, the same current flows anywhere in the circuit. This proves that the dielectric passes a current.

Action of Dielectric

The dielectric cannot pass direct current because it contains few free electrons. However, the electrons in the atoms of the insulator can be displaced, or moved out of their normal place, when a voltage is applied across the insulator. The electrons on plate Y of the charged capacitor (Fig. 2-8,B) have a repelling force on the electrons of the dielectric atoms. Similarly, plate X, being positively charged, has a strong attraction for these electrons. Therefore, the electrons in the dielectric, although they cannot leave their orbits in the atoms of the dielectric, actually shift to a new position. The shifting of electrons is an instantaneous current flow in the dielectric. As the current is caused by a displacement of the electrons in the orbits

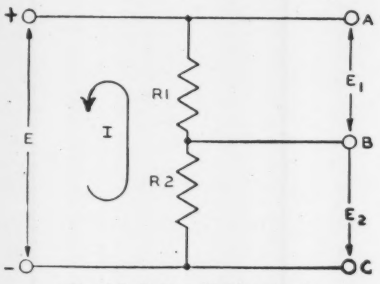


Fig. 2-7. Voltage-divider circuit.

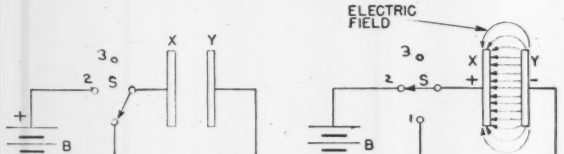


Fig. 2-8. Charging and discharging of a capacitor. A, discharged capacitor; B, charged capacitor.

of the dielectric atoms, the current is called *displacement current*. When the voltage is removed from a charged capacitor, the displaced electrons in the dielectric remain in their new positions in a state of strain. When the capacitor is discharged, the electrons return to their normal positions, thus giving a displacement current in the opposite direction.

As the electrons in the dielectric can vibrate back and forth, the capacitor can pass alternating current. However, as the electrons cannot move continuously in one direction, the capacitor cannot pass direct current.

The displacement current through the dielectric always is exactly equal to the normal electron current flowing in the circuit. Therefore, for all practical purposes, the two currents can be considered the same, and the current in the circuit can be considered as being the same at any point in the circuit.

The dielectric of a capacitor should be a good insulator. Even the best insulator, however, has some *leakage resistance*. The d-c. leakage resistance of a dielectric usually is greater than 1,000 megohms per uf. of capacity. Thus, a 0.01-uf. capacitor with 100 volts of applied d-c. potential leaks less than 0.001 microampere of d-c. current. (Electrolytic capacitors leak much more.)

Dielectric Constant

If mica instead of air is used as a dielectric, more current flows in the external circuit, the electric field is stronger, and the energy stored in the field is greater. This is because mica and other insulators are better conductors of electric

Continued on page 942

Pittsburgh's Temple *of* Research

FOREWORD

IN the last twenty years, *Instruments* has published factual descriptions of the most Instrumentation-conscious companies and institutions—universities, steel mills, airline bases, manufacturing plants, research laboratories, oil refineries, etc. Throughout these years, your editor has gathered such material in all parts of this country: Detroit (Mich.), Cambridge (Mass.), Cheyenne (Wyo.), Emeryville (Calif.) . . . but—such is human nature—we have introduced our readers to only a few of the many Instrumentation-conscious organizations in the city where *Instruments* is located.

Of all such institutions in Pittsburgh, none has a larger number—or higher proportion—of scientific and industrial Instrumenticians than has Mellon Institute. It is high time for *Instruments* to honor itself by honoring this great research organization whose management not only keeps up with advances in science but makes further progress possible.

Mellon Institute was founded in 1913 by Andrew W. Mellon and Richard B. Mellon to advance exact knowledge by discovery through research. The Founders looked upon natural science as capable of enlarging and refining life's satisfactions. Following the principles laid down by the Founders and subsequently fostered by their families, the Institute's researches are long-range in character and scope and pertain to important problems of human welfare, mainly in the fields of health, biology, chemistry, physics, and technology. The building—gift of the Founders—was occupied in 1937. The Institute has a cooperative alliance with the University of Pittsburgh, where its research system was initiated in 1910.

Mellon Institute has become both a national and a local science-center—not only because of its auditorium, its conference and social rooms, and its other facilities, but chiefly because of its scientists, their work and equipment. It has been the convention place of national scientific societies and allied associations. Likewise, committees of national technical organizations often come to the Institute for their sessions; and many leading professional groups of the Pittsburgh district hold their regular meetings there.

This is the first of two articles; the second will describe Mellon Institute's Department of Instrumentation.

M. F. BEHAR, Editor, *Instruments*

By WILLIAM A. HAMOR, Director of Research, Mellon Institute, Pittsburgh, Penna.

1. MANAGEMENT

MELLON INSTITUTE is a non-profit endowed corporation, whose Board consists of six Trustees—Messrs. Paul Mellon, Richard K. Mellon, Alan M. Scaife, John G. Bowman, Edward R. Weidlein, and George W. Wyckoff. Dr. Weidlein is Chairman of the Board and President of the Institute. As the Institute's President, he is assisted by a staff of Directors of Research, Drs. E. Ward Tillotson, William A. Hamor, George D. Beal, Leonard H. Cretcher and George H. Young, and by a Director of Engineering, Mr. Harry S. Coleman. Dr. John R. Bowman, Head, Department of Research in Physical Chemistry, and Mr. Howard C. Davies, Comptroller, are also members of this Executive Staff.

This staff constantly studies research methods, developments, facilities, and trends. It considers problems, and delineates and supervises acceptable investigational projects. It serves as a direct means of communication among the Institute's Departments (Organic Chemistry, Chemical Physics, Physical Chemistry, Analytical Chemistry, and Instrumentation) and the 80 different Fellowships with reference to common interests and to joint action. In all research programs of the Institute the range of effort necessitates the full time of the scientists. Altogether there are now 678 employees, of whom 80 per cent are in research, the remainder in servicing. The Institute keeps near to professional societies and to other research organizations, views investigational activities elsewhere, and maintains before it the concern of various governmental agencies in certain research programs.

In initiating and carrying on researches in branches of the pure and applied natural sciences there are the objectives of advancing required fundamental studies, of developing basic theory and standards, and of evolving

A corner in Mellon Institute's Physical Measurements Laboratory.

A low-temperature diffraction study with the Precession Camera.

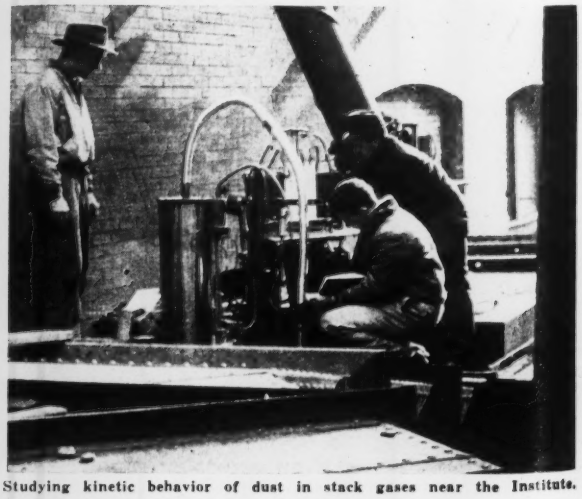
novel industrial processes and products and also new branches of manufacture. More than 1200 new or improved processes and products have come from the Institute's researches. Many contributions have been made to the literature, the publications totalling 2960, not including patents. In Mellon Institute pure or theoretical research and applied or utilitarian research progress together: advancement of the one makes easier the work of the other.

2. The Research Sphere of the Institute

The responsibility of scientific research is to construct a systematic and useful body of fact and theory. In Mellon Institute this duty is accelerated through directed teamwork in the interchange of underlying knowledge and ideas. The Institute is indeed a vehicle by which definite and valuable programs of research may be formulated and kept vital for scientists, not only within their specialties, but, with their collaboration, in interrelated subjects. More and more the Institute is being called upon to assist leaders in many phases of public life. Established knowledge of science and human relations can always render easier the solution of practical problems, particularly in the realm of health, involving sanitation, communal and industrial hygiene, and industrial economics.

So as to prepare for the expansion of its activities and services and for new undertakings, Mellon Institute has been strengthening as much as possible its research staff by acquiring specialists and also its facilities by providing more laboratories and by improving its equipment. During its past fiscal year, March 1, 1950, to March 1, 1951, the Institute expended $644,209 for pure research and $3,015,767 for applied research. And, in 1949-51, $1,940,590 has been spent on new construction to complete the facilities—the gift of Mrs. Ailsa Mellon Bruce, Mr. Paul Mellon, Mrs. Alan M. Scaife, and Gen. Richard K. Mellon, daughters and sons of the Founders.

Spectrochemical analysis by means of a two-meter grating spectrograph.



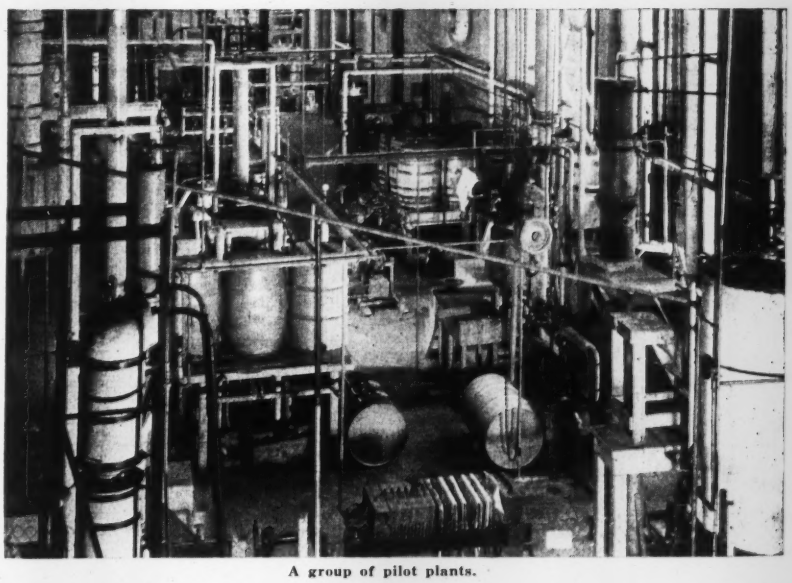
Studying kinetic behavior of dust in stack gases near the Institute.

An aim of the Institute is the development of research scientists for fertile careers there or elsewhere. As the years have passed, the variety, length and size of its research programs have been increased, encouraging the building up of personnel through long-continued judicious selection. The professional and social structure of the whole Institute group—the executive, research and servicing staffs—is given substance by the Robert Kennedy Duncan Club, the organization of the members that keeps alive the name and spirit of the first Director. A strong research tradition is thus nourished that is integral to the fulfillment of the Institute's functions.

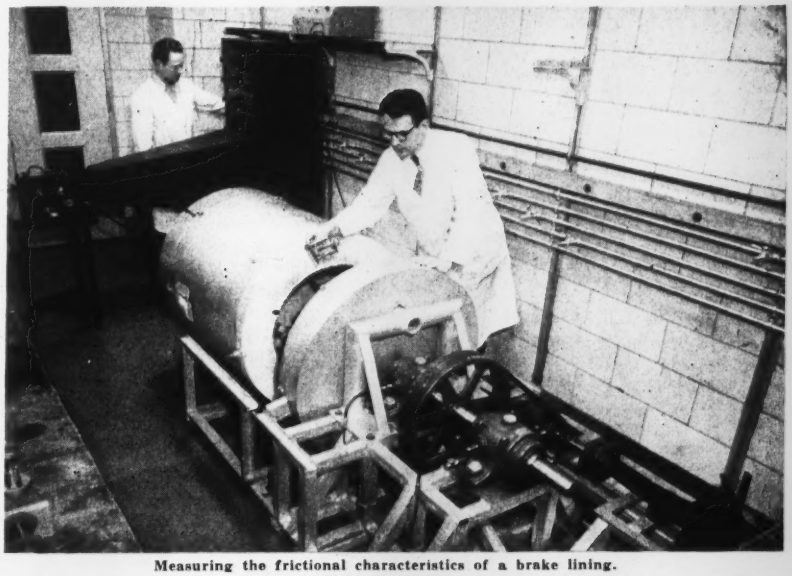
3. Researches in Pure Science

Mellon Institute, recognizing fully the need of fundamental scientific research as a background and source of stimulus for applied science research, supports numerous pure science investigations planned within the organization. The Institute's Department of Research in Organic Chemistry, which studies largely the synthesis of new drugs, has had a fruitful life. The Departments of Research in Chemical Physics (with spectroscopic and x-ray divisions) and in Physical Chemistry (with its physical measurements laboratory) apply their methods and techniques in aid to Fellowships and in basic studies of their own choice. Expertness in technique, as first brought out in analytical chemistry, is a goal of the research scientist's work. High skill in that elaborate thinking and doing has been very much facilitated by developments in physical chemistry and chemical physics and in their comprehensive instrumentation. The Institute sustains a well-equipped Department of Instrumentation.

Also in the field of pure science research, Industrial Hygiene Foundation, a nonprofit national association for advancing health in mining and the manufactures, operates productively as a Fellowship under the Institute's auspices. Then, too, the programs of seven Fellowships maintained by government



A group of pilot plants.



Measuring the frictional characteristics of a brake lining.

Determining nitrocellulose solution viscosities for lacquer technology.

Examining the condition of a steel strip surface.

(state and federal) and by private organizations are likewise in pure science. These Fellowships pertain to artists' materials, chemical hygiene, computing-machine components, industrial dusts, mine-acid control, orthopedic appliances, and synthetic rubber properties. Altogether, in 1950-51, 102 members of the Institute have been engaged in pure science research projects.

The results of all these pure science investigations are made available to the professions and the public.

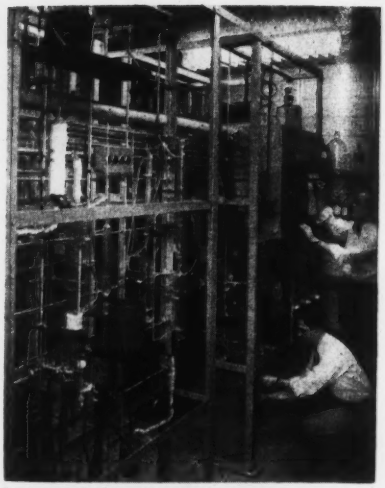
4. Linking Research to the Needs of Technology

Acting for the industries by annual contracts with companies, Mellon Institute conducts, through 72 other Fellowships, applied science research in as many important technologic areas. Such Fellowships are supported at operating cost by funds provided by company donors and are awarded to scientists on the basis of competence. In the Institute, although every Fellowship has reserved for it a definite field of research, almost always there are convergences with various related fields and with problems in the application of research as a force for the help of mankind. The Institute has led in synthesizing this force by dependable methods, by the advancement of scholarly inquiry, and by the encouragement of adequate training for research. The larger Fellowships in particular give research experience to young scientists of promise by their work under experts. Although the researches of all Fellowships are of postdoctoral status, junior members of Fellowship staffs may have the opportunities of local graduate study, especially in the University of Pittsburgh.

Among the recent achievements in applied science researches of the Institute are improvements in refractories, porcelain enamels, optical glass, and building materials; and important additions to the knowledge and practice of steelmaking, steel construction, welding, and metalworking. The Institute is active in helping the by-product coke industry to map its future and in investigating recovery processes and methods for utilizing coal chemicals. Its work in petroleum chemistry and technology is also recognized internationally as authoritative. On other Fellowships new solvents, hydraulic brake fluids, adhesives, waterproofers, lacquers, and leather and wood finishes are being evolved for the industries; new foods are being studied, sugar refining is being bettered, novel products from corn and soybeans are being examined for applications of value, and textiles and paper are getting improvement. New kinds of plastics, novel protective coatings for metals, new types of floor and wall coverings, new and useful organic compounds of silicon and of silicates, better cold-climate equipage, new insecticides, and new medicinal agents are coming from still other Fellowships. Fellowship investigations of industrial waste utilization and of air and water pollution control are especially well known.

5. Conclusion

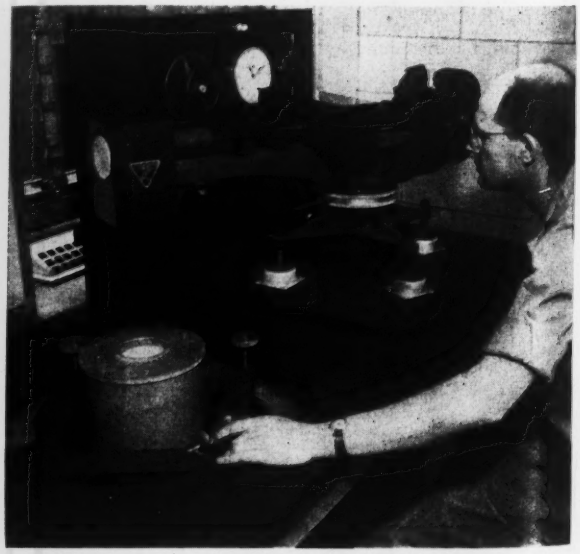
Experience in World War II demonstrated that a nation is no stronger than its sciences and industries, that the sciences and industries are no stronger than their manpower. Activating the community to a better appreciation of the sciences and their human relations, pointing out to the industries wherein scientists can be of assistance and thereby winning support for research, prosecuting investigations directed to public needs, and turning out skillful research men, Mellon Institute has a forty-year history of pioneering service in ministering through scientific research to the well-being of mankind.



Instrumentation employed in a research on sulphur recovery from petroleum.

Heavy hydrogen in use in a program on catalytic cracking.

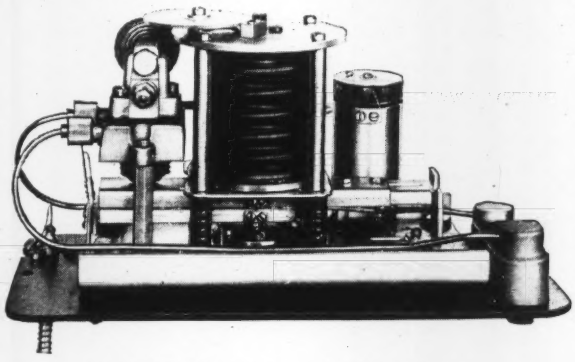
A binary-to-octal digital converter employing neon diodes.



Adjusting an experimental recording thermal dilatometer.

DYNAMIC ACCURACY means more today than ever before!

Accurate Measurement of changing temperatures and pressures is the vital first step in instrumentation, whether indicating, recording or controlling. Today, TRANSAIRE* Transmitters set new standards for sensitive and accurate measurement.



TEMPERATURE:

Taylor TRANSAIRE Temperature Transmitter with Speed-Act* lets you measure and transmit smallest temperature changes up to 1000 feet with great accuracy! The *only* temperature transmitter that gives you:

1. DYNAMIC ACCURACY—which means the accuracy of an instrument in measuring changing or dynamic conditions. TRANSAIRE Dynamic Accuracy is unparalleled. Solves the problem of process engineers who realize that an instrument accurate to a fraction of a degree in measuring static conditions can be in error by many degrees when temperature is changing.

2. DYNAMIC COMPENSATION—which means ability to compensate for inherent lags both in measuring system and rate of heat transfer of process medium. TRANSAIRE does this by introducing derivative action (Speed-Act) into *measuring* circuit. The result is Dynamic Accuracy, with a speed of response seldom thought possible, permitting much closer automatic temperature control.

TRANSAIRE is the first step in Taylor's TRANSET* Control System. Step No. 2 is either Taylor's three-response TRI-ACT* Controller, or the lower cost, BI-ACT* Controller which gives stability with one adjustment. Step No. 3 is the Taylor TRANSET Recorder or Indicator. All three combine into the famous Taylor TRANSET Control System. **Write for Bulletin 98097.** Taylor Instrument Companies, Rochester, N. Y., and Toronto, Canada.

Instruments for indicating, recording and controlling temperature, pressure, humidity, flow, liquid level, load, speed and density.

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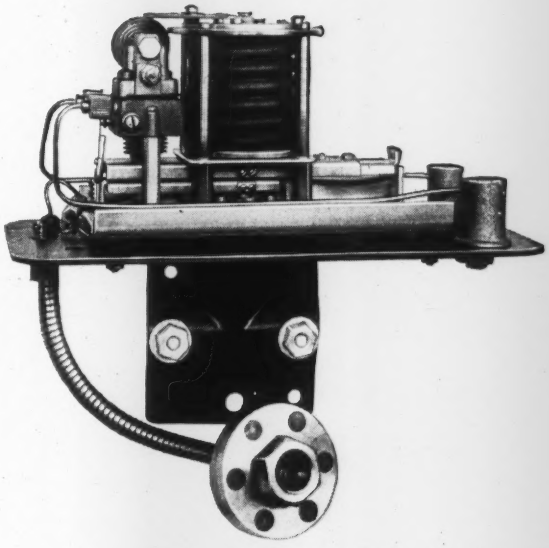

PRESSURE:

Taylor TRANSAIRE Pressure Transmitter with narrow range spans lets you measure and transmit minute pressure changes up to 1000 feet. Works on simple force-balance principle. Accurate to ½% of the selected short range span (*conventional devices are only accurate up to ½% of upper range limit*). Sensitive to pressure changes of ½" water. Here's accuracy and sensitivity never before thought possible in measuring process pressures—plus the convenience of suppressed ranges at high pressure levels.

THREE IMPORTANT ADVANTAGES:

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2. Volumetric type pressure system is extremely accurate, practically clog-proof, has corrosion-resistant 316 stainless steel diaphragm.

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New Principles, Applications, Non-commercial Developments

Miniature Transmitter

SILVER SPRING, Md.—A radio transmitter the size of a cigarette package and with range of 20 to 100 miles (depending on distance off ground) has been developed by the Applied Physics Laboratory of The Johns Hopkins University in Silver Spring, Md., for use in the nose of a rocket. The transmitter collects data from radio-telemetering pickups and relays them to ground recorders. It operates in the 200-Mc. band and has a power output of 2 watts minimum. Its deviation sensitivity is plus or minus 50 kc. per volt rms. As many as 60 separate sources of information can be telemetered during a flight test.

Pipe-line Pressure Measurement

PHILADELPHIA, Pa.—Pressure measurement and control of the entire Plantation Pipe Line system between Baton Rouge, La., and Charlotte, N. C. will be effected by resistance-wire strain-gage (SR-4) pressure cells. Pressure variations are transmitted to an instrument panel by 4-8 volt lines carrying less than 0.1 ampere of current and using less than one watt of power.

Of nearly 200 pressure cells to be in use, those used with indicating instruments will have capacities ranging from 600 to 1500 psi. and those used for automatic control will have 1000-psi. capacity.

A pressure cell consists of a pressure-sensitive tube connected into the pressure system. Resistance-wire strain gages are bonded on the outside of the tube. Slight expansion or contraction of the tube, caused by pressure changes, stretches or relaxes the fine wire grids of the gage, increasing or decreasing its electrical resistance. This change of resistance is measured by various types of indicating or recording instruments or automatic controllers commanding the pumps.

Oil-line Products Tracked by Radioactivity Recorders

PHILADELPHIA, Pa.—A new and efficient method of keeping track of different petroleum products flowing through a common-carrier pipe-line has been developed by Standard Oil Co. of California. The system uses minute amounts of radioactive tracers. It is being used on the new 566-mile line from Salt Lake City to Pasco, Washington.

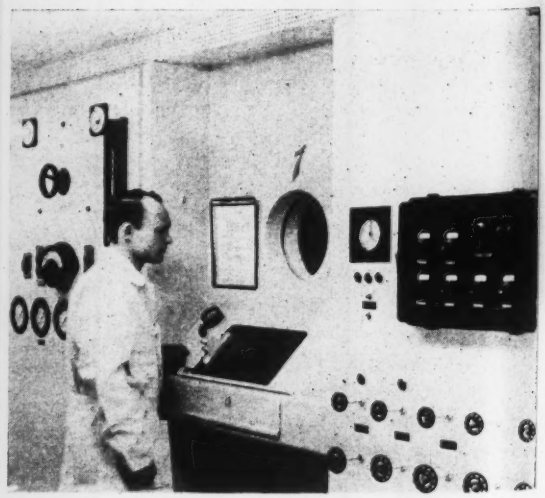
There are many different products—from diesel oil to high-octane gasoline. There are many take-off points. Relatively small amounts of product are taken off at any one point, and the pipe-line is a long one. For these reasons, none of the common methods of identifying line contents seemed satisfactory. The radioactive tracers provide dependable markers between products and thus assure proper handling.

Each time the Salt Lake Pump Station changes product, a fraction of an ounce of diluted tracer liquid is injected into

Indicating Controllers Speed Tests of Engine Fuels and Lubricants

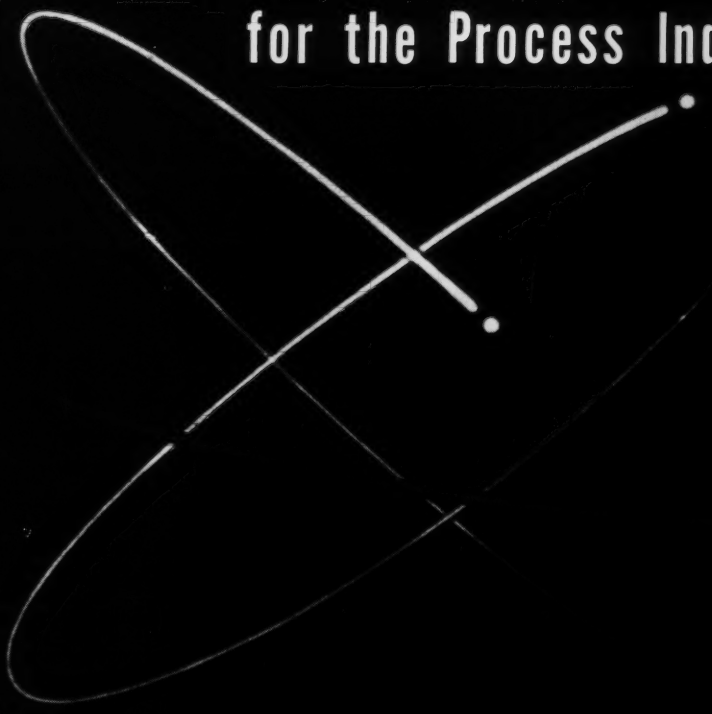
MARTINEZ, Calif.—A substantial increase in the number of testing units one operator can handle is the time-saving advantage of twelve multiple-point automatic controllers installed in the Research Department of Shell Oil Company's Martinez Refinery. Replacing units that were manually operated, the battery of instruments is used for indicating and controlling temperatures in the laboratory testing of fuels and lubricants. Each of the twelve "TAG Celectray Multiple Point Indicating Potentiometer Controllers" has six control points. Six tests can thus be controlled at one time by one instrument, with a total of 72 tests when all 12 units are in operation.

In the Martinez installation, the controllers are part of Shell's Motor Laboratory equipment that tests the use of oils and lubricants in engines ranging in size from one cylinder to the largest motors of trucks and tractors. Ten of the six-point control units are used on engine test stands for controlling the flow of additional cooling water or steam to engine jackets, oil heat exchangers, fuel heat exchangers, and comparable equipment. Two of the units are used with bearing test machines for controlling electric heaters which maintain desired temperatures. The controllers are made by Tagliabue Instruments Division, Weston Electrical Instrument Corporation.



(Left) Battery of engine test stands at Shell Oil Co.'s Motor Laboratory. (Right) One of the instrument stations, showing six-point indicating potentiometer-controller.

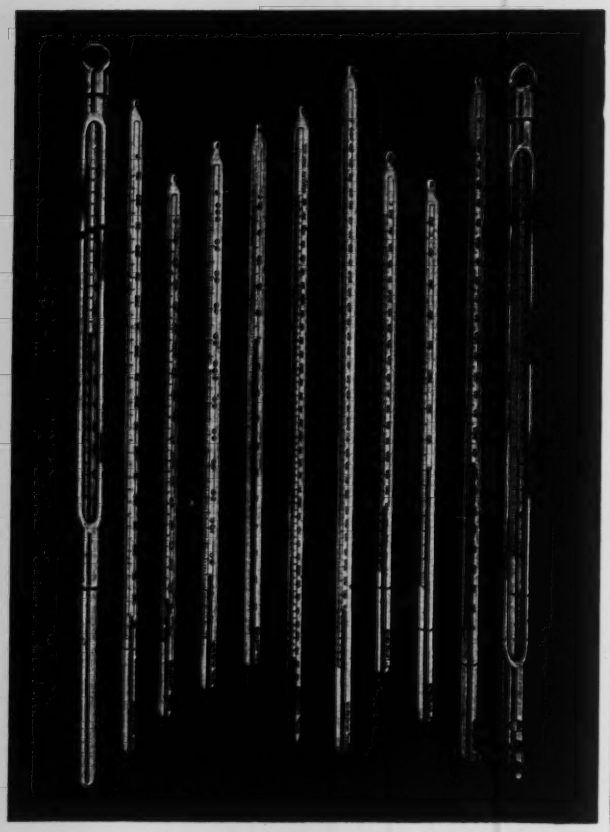
A revolutionary new electronic control system for the Process Industries



You are cordially invited to inspect the new Swartwout Autronic Control System for precise, automatic measurement and control of temperature, pressure, level, and flow. This compact electronic system is the ultimate in centralized control. It will be publicly displayed for the first time at the Sixth National Instrument Exhibit, Houston, Texas, from September 10th to 14th, inclusive. We look forward to seeing you at Booths 324-346. Or if you are unable to attend in person, write for literature on the new Swartwout Autronic Control System.

Swartwout *Autronic* CONTROL SYSTEM

THE SWARTWOUT COMPANY, 18511 EUCLID AVENUE, CLEVELAND 12, OHIO



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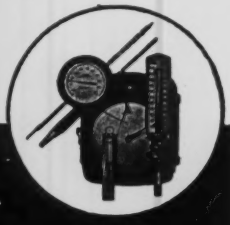

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the line at the interface or boundary between products. This liquid contains about a billionth of an ounce of radioactive antimony compound prepared at Oak Ridge.

As the junction of the two products moves along the line, the tracer naturally flows with it. At each take-off point, Geiger-Mueller counting tubes are strapped to the pipe to detect passage of the radioactive interfaces. Output from the Geiger tubes is fed through amplifiers into a counting rate meter, which, in turn, is connected to a "Micromax" recorder. As the interface passes the Geiger tubes, the recorder describes a sharp peak in its radioactivity curve and so signals the arrival of the new product.

With this new method of identification, station operators need not waste hundreds of hours a year standing by to "catch" interface passage when a cut is to be made in the oil stream. Their recorders tell them exactly when one product has passed the cut-off valves and allows them to switch the new stream of gasoline or oil to the proper tank. Local reports sent to Salt Lake City enable the pipe-line dispatcher to keep close control over all products in the line.

This new method is absolutely safe. Peak radiation is less than that of a luminous wrist-watch dial. The radioactive material is also self-destroying; its radioactivity disappears soon after it reaches a tank. The new development is the subject of patent applications by the California Research Corporation, a subsidiary of Standard Oil Company of California.

Electric-circuit Printers

WASHINGTON, D. C.—Two semi-automatic machines for printing electric circuits, one for flat surfaces and the other for cylindrical surfaces, have been developed recently at the National Bureau of Standards, according to Technical Report 1548. The new NBS printers are products of a continuing program of printed circuit development sponsored by the Navy Bureau of Aeronautics. Although few if any automatic printers have been developed for printed-circuit applications, such printers offer two important advantages. First, they are faster than hand printers and more economical for use in quantity production. Second, they give a more uniform product.

Printed circuits—in which wiring and components are superimposed directly on insulating bases—are being used increasingly because they can be economically produced in quantity and because they facilitate miniaturization of equipment. Circuits usually are printed manually by a stenciled-screen process in which a rubber squeegee forces silver paint onto the insulating base through openings in a fine silk or metal screen. Firing of the printed plates then drives off the paint vehicle and leaves an adherent silver film of high conductivity.

The NBS printer for flat plates (Fig. 1) is motor-driven

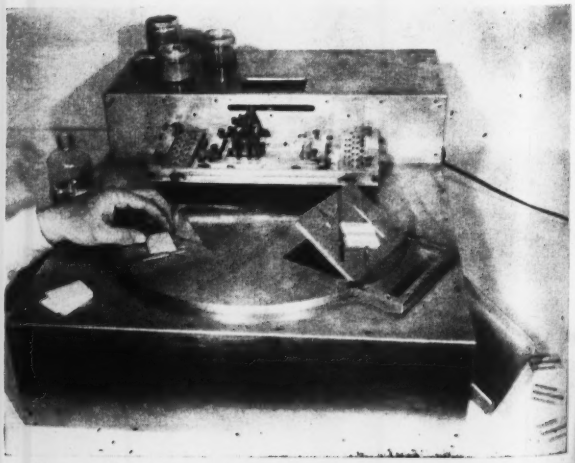
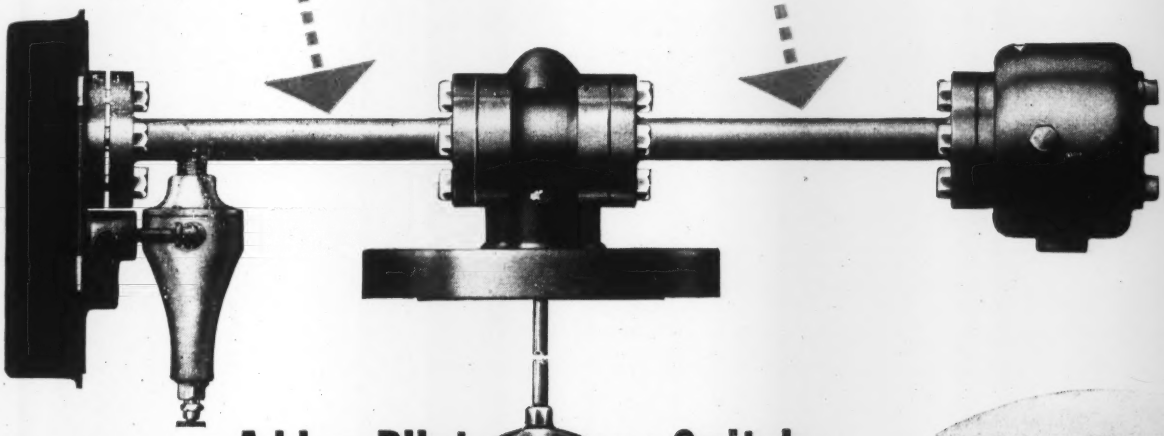


Fig. 1. Automatic circuit printer for flat surfaces. The ceramic plate being loaded on the turntable (left) will be carried to the rear of the machine, where a silver circuit pattern will be impressed on it.

EXCLUSIVE DUAL TORQUE TUBE



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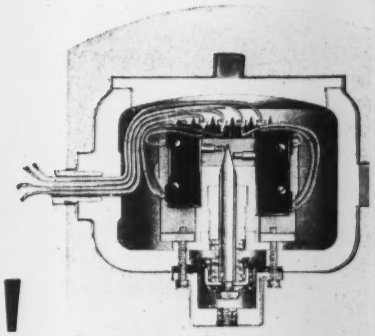
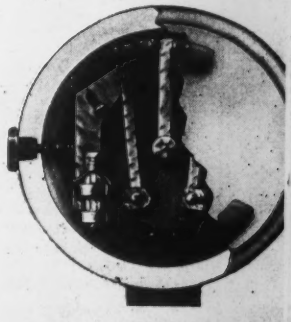


Type 2112 Explosion Proof Pressure Switch designed to operate as man as three circuits from an pressure source with as muc as five pounds range. Uniqu diaphragm-operated desig gives longer, trouble-free lif Gas-tight. Easily wired an mounted.



Type 2122 Magneti Switch utilizes the turnin movement of the Type 88 torque tube to actuat switches. Sensitive to a min mum change of 10% of th length of the displacemen element. Explosion-proc cover. Mounts easily on an BS&B "Climax" liquid leve control.

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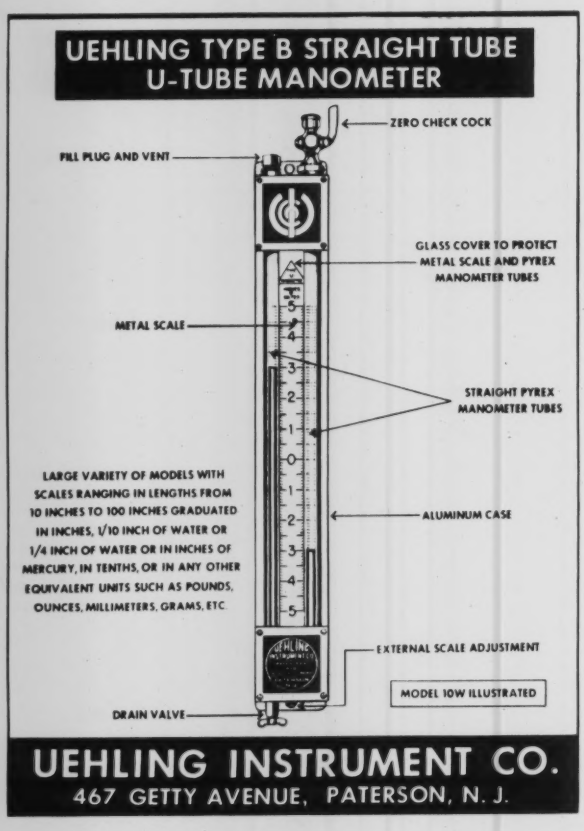
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MODEL 10W ILLUSTRATED
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and more fully automatic than the printer for cylindrical surfaces (Fig. 2). In the flat-plate printer, a turntable accepts the unprinted plate at a loading position, carries it to a printing position, then carries the printed plate to an unloading position, where it is automatically flipped into a chute.

In regular operation, three plates are processed simultaneously. While the first plate is unloaded, the second is printed, and the third is loaded. The turntable stops while these operations are performed, then advances the plates one-third of a revolution, stops again, and so forth. The usual production rate, about 1000 plates per hour, can be increased to 1500 per hour without loss of printing quality, but at the expense of excessive wear and tear on the machine.

As the turntable advances the plates from position to position, they rest on rectangular platens about 3 by 4 inches in size. These flat platens are normally flush with the turntable. However, when a plate-carrying platen reaches the printing position, the platen rises and presses the plate against the underside of the printing screen, which occupies a fixed horizontal position. While the plate is held against the screen, a rubber squeegee is moved automatically

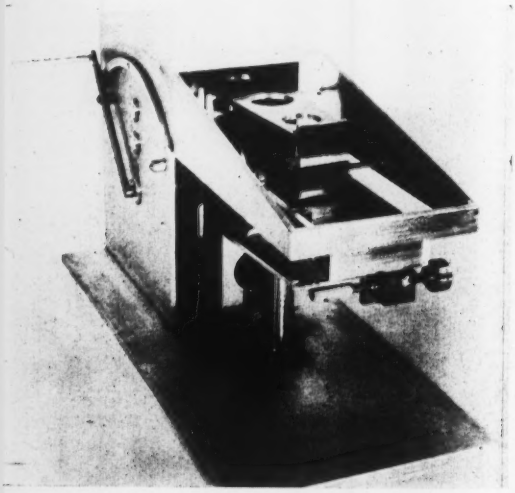

Fig. 2. Semi-automatic printer for cylindrical surfaces. A single forward-and-back stroke of the control lever (left) puts the machine through an entire printing operation and drops off the printed cylinder.

over the top surface of the printing screen, forcing conducting paint through the screen onto the plate in the desired pattern. The platen is then lowered to its flush-with-the-turntable position and is advanced by the turntable another third of a revolution to the unloading position. Here the platen is tilted, and the printed plate slides into the discharge chute.

The flat-surface printer is at present loaded by hand, one plate at a time. The rest of the process is automatic.

The NBS cylindrical-surface printer (Fig. 2) was developed for the printing of cylindrical ceramic forms less than 0.5 inch in diameter. Such small ceramic cylinders are usually out-of-round and present a much more difficult printing problem than larger, more perfect forms.

The cylindrical-surface printer is loaded manually by slipping the cylinder to be printed over a mandrel. A single stroke of a hand-operated control lever then puts the machine through the entire printing cycle and operates a release mechanism which drops off the printed cylinder.

With hand loading of the cylindrical surface printer, an operator can print 1500 cylinders in an 8-hour day. An automatic feed mechanism and electric drive, which could be added without much difficulty, should increase the production rate to 500 to 1000 cylinders per hour. For fully automatic production at high speed, a conveyor belt system with steadying pins also could be added to carry away the printed cylinders.

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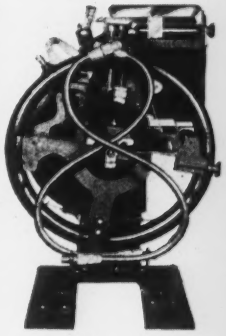
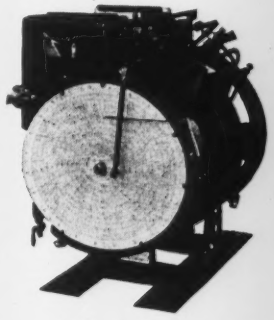
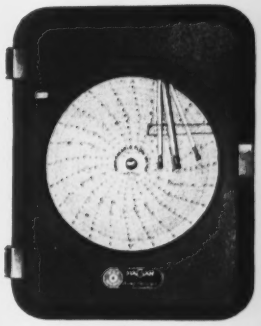


Back view of single ring, high differential meter, showing S-tube connection.



Front view of dual meter with one high differential and one low differential ring.



Front view of three-pen meter in case. Panel space is the same for all models.

ISA's SIXTH ANNUAL EXHIBIT

DESCRIPTIVE LIST of EXHIBITS and PERSONNEL in ATTENDANCE

HOUSTON COLISEUM Sept. 10-14, 1951

Acragage Co.
Milford, Conn. 243

Exhibiting: Acragages; Graphic panel gages; Pneumatic and electric transmitters; Custom Acragages; Instruments for measurement of pressure.

In Attendance: Arthur S. Brown, Pres.; A. E. Campbell, S.M.; Frank Esch, Jack Walker, Dave Founds, of Esch Condit, Inc.; Doc Arduser, Ardun Supply Co., Tulsa; W. A. Griffin, P. M. Vickery, Daniel Orifice Fitting Co.

Agricultural and Mechanical College of Texas
College Station, Texas 606

Exhibiting: Proceedings for all five previous symposia will be on sale. First four $2.00 each; Fifth—$2.50. The A & M Symposia were founded to meet the needs of instrument men in the Southwest.

In Attendance: Dr. G. L. Farrar, Director of Symposium; L. W. Parten; Dr. J. D. Lindsay; Homer Givens; M. K Anderson.

Air Clocks, Inc.
Huntington Station, N. Y. 109, 111

Exhibiting: Air Clock, pneumatically-powered drive for circular-chart recording instruments.

In Attendance: C. H. Thompson, S.M.; H. S. Garrett, R. A. Barnes, W. B. Miller.

Aircraft-Marine Products Inc.
Harrisburg, Pa. 509

Exhibiting: New Products—Nylon insulated terminals, (Strato-line); Nylon closed-end connectors; Bomb-tail connectors; Electric hydraulic tools; Pre-insulated flag terminals; Hand hydraulic tools; Identification bands; Line-tap connectors; Boat-leg connectors. **Regular Products**—AMP solderless terminals and connectors; Precision hand tools, presses and automatic machines. Engineering service on special termination problems and unusual installations.

In Attendance: T. R. Betts; C. T. Dykes, Branch Mgr.; R. M. Gibboney, Sales Rep.; R. J. Vizcarrondo, Operations Mgr.

Alina Corp.
New York 4, N. Y. 438

Exhibiting: New Products—Pneumatic chart drive; Mechanical chart drive, specifications of Recorder-Controller Section, S.A.M.A. **Regular Products**—Chart drives for cylindrical, circular and strip charts; Pressure gage movements; anemometer movements; time switches; interval timers; x-ray hand timers; Parts, differentials, pinions, worms, etc.; Sub-assemblies for all industry.

In Attendance: Fred Senn, Sales Engr.

American Institute of Electrical Engineers
New York 18, N. Y. .....M. C.*

Exhibiting: AIEE Publications; Information concerning AIEE.

In Attendance: Members of the Local AIEE Section.

American Meter Co.
Philadelphia 2, Pa. 101, 103, 105

Exhibiting: New Products—Series A-88 orifice meter for 5000# W.P.; Flapper type differential valve providing single or double outputs for control of shut-off valves, spring-loaded or cylinder-operated; Square root flow Transmitter, pneumatic signal giving linear of flow at the receiver; Polypneumatic set controllers, sets the control point in accordance with the sum or difference product or ratio of two incoming signals; HL and KL Regulators, high capacities at low differentials; KU Regulator combines characteristics of the HL and KL and includes a union connection between the valve unit and body. **Regular Products**—Standard A-88 orifice meters; Transmitters; Receiver controllers.

In Attendance: W. G. Hamilton, Jr., Pres.; D. C. Wiley, V.P. Research; C. B. Dushane, V.P. Sales; R. Gray, Physicist; W. R. Kehoe, Research Engr.; A. B. Cloud, R. D. O'Neil, Dist. S. Mgrs.; P. E. Crane, W. Rowan, B. S. Truett, Sales Engrs.; L. V. Hickman, A. Costa, G. W. Stevenson, J. E. Gesner, C. Braswell, R. F. Conners, Engrs.; J. H. Satterwhite, Pres. Wescott & Greis; C. H. Clover, Mgr. Northern Div. Westcott & Greis; H. W. Wahl, Engr. Southern Div Westcott & Greis.

*Members' Center

American Society of Mechanical Engineers
New York 18, N. Y. .....M. C.*

Exhibiting: Publications of A.S.M.E. pertaining to Industrial Instrument and Regulator Division.

In Attendance: Members of the Industrial Instrument and Regulator Division.

Ampex Electric Corp.
Redwood, Calif. 311

Exhibiting: Magnetic tape recorders for audio and instrumentation applications.

In Attendance: M. J. Stolaroff, Ass't. Ch. Engr.; E. G. Swanson, Sales Mgr.

Anders Co.
Philadelphia 44, Pa. 445

Exhibiting: New Products—Prefilter (Hiairflo Oil Prefilter) for installation in compressed-air lines ahead of desiccant type dryers to remove oil. **Regular Products**—Semi-automatic Type SA compressed air dryer; Fully-automatic Type FA compressed air dryer.

In Attendance: Edwin W. Anders; Stanley S. Williams; George Norwood; Joe H. Palmer; M. N. Dannenbaum; Neal Mannon; Pete (F. R.) Bartlett.

The Annin Co.
Los Angeles 23, Calif. 406, 408

Exhibiting: New Products—Shuttlrator control valve for higher pressure-drop application in larger valve sizes provides 1000-to-1 rangeability; Strokemaster high-speed pneumatic cylinder operator providing 500, 1000, 2500 pound thrust with 4, 6, 8 inch strokes, built-in positioner for stroke speeds of 2 inches per second. **Regular Products**—Model 1560 Domotor control valve; Model 1520 electropneumatic solenoid-operated valves; Fig. 15 manually-operated throttling valves.

In Attendance: D. H. Annin, Mgr.; R. D. Randall, Ch. Engr.; F. M. Esch, J. C. Walker, Jack Dugan, D. G. Founds, Houston Reps.; W. J. Gallagher, Phila. Rep.; H. W. Johnson, N. Y Rep.; P. B. Shannon, Chicago Rep.

Ashton Valve Co.
Wrenthen, Mass. 728

Exhibiting: Safety valves; Pressure gages; Gage testers.

In Attendance: B. H. Stolpestad, Ch. Engr.; O. L. Patrick, Sales Engr.

Askania Regulator Co.
Chicago 11, Ill. 106, 108

Exhibiting: New Products—Differential Pneumatic transmitter. **Regular Products**—Oil meter and assembly; Valve positioner; Pneumatic hydraulic positioner; Automatic hydraulic controls.

In Attendance: H. Ziebolz, V.P.; W. W. Wheeler, S.M.; N. Berman, Project Engr.; S. Jones.

Assembly Products, Inc.
Chagrin Falls, Ohio 702

Exhibiting: New Products—Simplytrol special-purpose controls, single and double contact meter type control assemblies for measurement and control of temperature, voltage and current; Simplytrol Poly-Points, multiple meter controls for space saving. **Regular Products**—Panel meters; Pyrometers; Contact meter-relays; Controlling pyrometers; Snap-action relays.

In Attendance: Bradley Thompson, Pres. & S.M.; Agnes Thompson; James J. Murley, Sec.-Treas.; Mrs. J. J. Murley.

Automatic Electric Sales Corp.
Chicago 7, Ill. 132

Exhibiting: New Products—Type 44 rotary stepping switch, miniaturized telephone type, 6-pole 10-point to 2-pole 30-point capacity; AN Type hermetically-sealed relays with stud or plug-in mountings. **Regular Products**—Telephone type relays and switches. Design and manufacture of remote control switches for monitoring and switching.

In Attendance: V. E. James, Mgr. Relay Sales; A. R. Tindell, Ass't. Mgr. Relay Sales; D. K. Allen, Sales Engr.

Automatic Temperature Control Co.
Philadelphia 44, Pa. 743, 745

Exhibiting: New Products—Duo-Set automatic reversing time controller featuring separate adjustments of two electrical control circuits; Pneumatic time cycle controller featuring new poppet valve for higher pressures and greater capacities; Atcotran process monitoring system, a linear differential transformer instrumentation system featuring electrical transmission for process variables such as flow, pressure, level, vacuum, weight, position. **Regular Products**—Motorized valves; Time controls; Atcotran recorders and control instruments.

In Attendance: W. W. Winters, S.M.; W. E. Brice, Houston Rep.

Bailey Meter Co.
Cleveland 10, Ohio 141, 143, 145

Exhibiting: New Products—Mini-Line Equipment, miniature indicators and control units for power and process applications; Mini-Line Equipment mounted on console type or graphic type centralized control panels saves 50% panel space compared with requirements of standard size counter part equipment. **Regular Products**—Fuel flow-air flow ratio meters; Flow meters, area type; Resistance thermometers; Electronic telemeters; Pneumatic control systems; Electronic recorders. Applications of meters and controls for power and processes.

In Attendance: H. M. Hammond, V.P.; C. M. Kunkel, Mgr. Houston; C. E. Albert, Mgr. Kansas City; S. G. Dukelow, Mgr. New Orleans; M. J. Bonnette, F. H. Fellows, Sales Engr.; L. E. Bartel, W. D. Hilborn, R. W. Hooper, M. G. Johnson, Mech. Engrs.; E. B. Bossart, Adv. Mgr.

Baird Associates, Inc.
Cambridge, Mass. 215

Exhibiting: Plant Gas Analyzer.

In Attendance: Joseph M. Devine, P. C. Hutchinson, Sales Engrs.; George Ogden, Engr.; Leroy Lyons, Inst. Ser. Engr.

Baldwin-Lima-Hamilton Corp.
Eddystone, Pa. 107

Exhibiting: New Products—Instrumentation of SR-4 load, pressure and torque measuring devices with special emphasis on use of pressure cells in chemical processes and oil pipe lines; Functional display of SR-4 strain gages. **Regular Products**—SR-4 strain gages; SR-4 strain gage instruments; SR-4 strain gage devices.

In Attendance: M. L. Hall, Mgr. Test Equip. Dept.; B. L. Sutton, Electronic Sales Engr.; Wm. A. McKnight, Houston Dist. S.M.

Barton Instrument Corp.
Los Angeles 22, Calif. 330

Exhibiting: Model 200 differential pressure indicator, Model 202 differential pressure recorder, both rupture-proof stainless steel bellows. Design of flow, level and differential pressure measurement for refineries, oil fields, chemical plants, aircraft engine testing.

In Attendance: Claude B. Nolte, V.P.; Robert Aitken, Allen G. Brown, Robert Hazzard, Reps.

Beckman Instruments, Inc.
South Pasadena, Calif. 144, 146

Exhibiting: New Products—Model N completely portable pH meter; Flame photometry attachment (for Model DU quartz spectrophotometer and Model B spectrophotometer) features integral atomizer with virtually clog-proof palladium capillary. **Regular Products**—Model IR-2T recording infrared spectrophotometer; Model B spectrophotometer; Model DU quartz spectrophotometer; Model K automatic titrator; Model R pH indicators; Beckman glass electrodes; Flow colorimeter.

In Attendance: A. O. Beckman, Pres.; T. F. Herring, S.M. & V.P.; R. W. Moulton; J. W. Gerrard, Mgr. Sales Dept.

James G. Biddle Co.
Philadelphia 7, Pa. 638

Exhibiting: New Products—TTR transformer turn ratio test set; Megger low-resistance ohmmeter, battery operated and rectifier operated types for resistance between 100 and 10000 microhms; Dr. Horn tachometer, hand centrifugal, 5 ranges 25 to 3000 rpm, protected against overspeeding. **Regular Products**—Megger insulation testers and ground testers; Jagabi speed measuring insts.; Frahm resonant-reed tachometers and frequency meters; Jagabi rheostats.

In Attendance: Earl Lipscomb Associates, Reps.

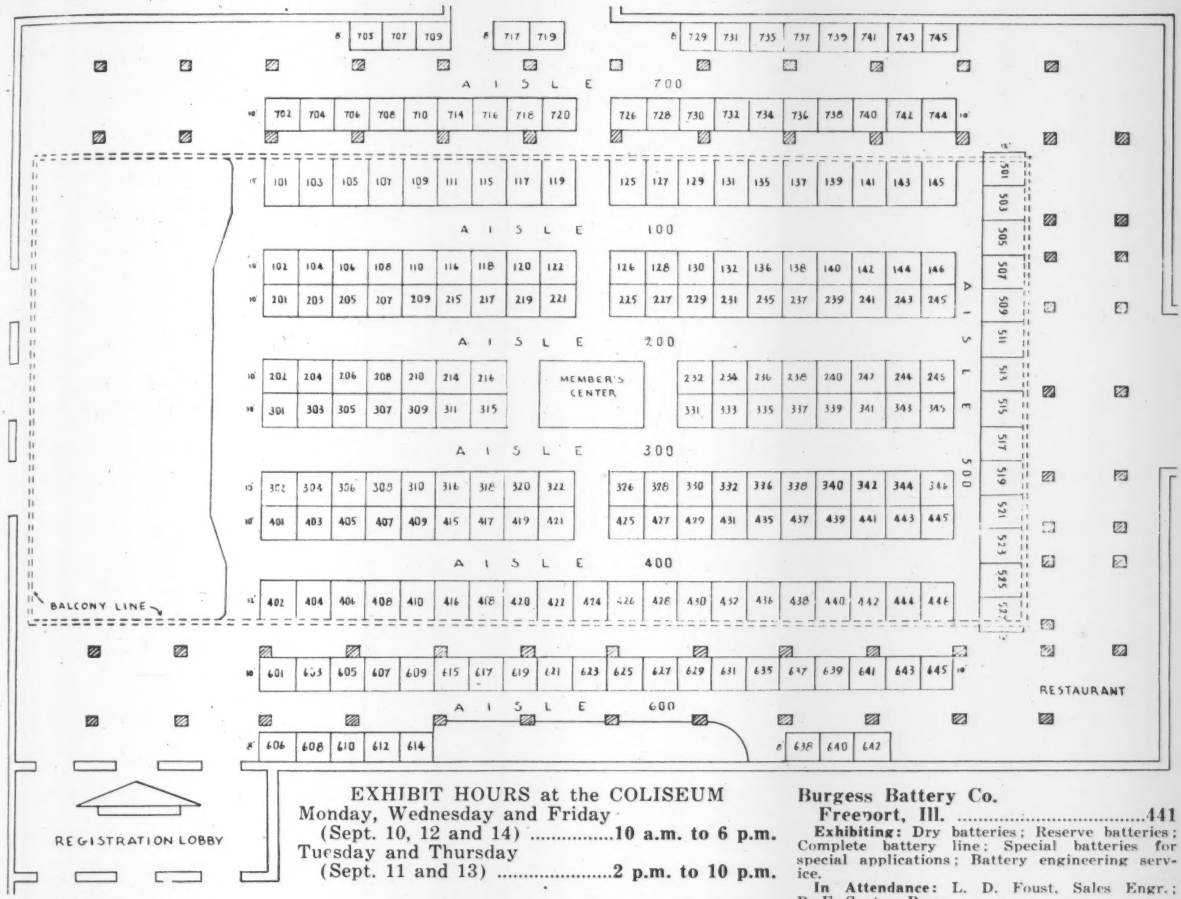


EXHIBIT HOURS at the COLISEUM

Monday, Wednesday and Friday (Sept. 10, 12 and 14) .....**10 a.m. to 6 p.m.**

Tuesday and Thursday (Sept. 11 and 13) .....**2 p.m. to 10 p.m.**

Black, Sivalls & Bryson, Inc. Climax Controls Div.
Tulsa, Okla. 237, 239, 241

Exhibiting: New Products—Type 115 angle free-flow control valves; Type 40-45-4AML ball float controller, Mercoid switch and pilot, high-level or low-level alarm or shutoff, manual reset; Type 875D bellows seal valves, compact topwork design and wide inner valve range-ability. **Regular Products**—Displacement liquid level controllers; Diaphragm control valves; Pneumatic relays; Pressure controllers.

In Attendance: Jimmy Dvoracek, Mgr. of Sales; Ross B. Baze, S.M.; A. J. Hanssen, Ch. Engr.; W. M. McGinnis, J. E. Watson, A. E. Erickson, Boyd J. Smith, O. J. Waguespack, J. S. Simmons, T. C. McGuire, Howard Wharton, H. V. Peoples, T. F. Casey, P. E. Bowles, Salesmen.

William E. Brice Co.
Houston, Texas 743, 745

Exhibiting: Automatic weighing, packing and proportioning machinery for dry and liquid materials (Richardson Scale Co.); Atcotran motorized valves and special controls (Automatic Temperature Control Co.); Insulation testers and tachometers (Herman H. Sticht Co.)

In Attendance: Walter Young, Richardson Scale Co.; Walt. W. Winters, Automatic Temperature Control Co.; Jerry Brice, Gene Brice, Wm. E. Brice Co.

Bristol Co.
Waterbury 21, Conn. 115, 117, 119

Exhibiting: New Products—Strip-chart air-operated electronic potentiometer; Strip-chart multiple-record electronic potentiometer; 2-pen strip-chart electronic Dynamaster potentiometer; Round-chart electronic Dynamaster potentiometer; 24-point indicating electronic Dynamaster potentiometer; Continuous telemeters; Series 500 recording voltmeters and ammeters; Series 500 pneumatic transmission system; Uniform-chart vapor-tension recording thermometer; Bellows differential flow meter. **Regular Products**—Metameter telemeters; absolute pressure recorders; Series 500 air-operated controllers; Dynamaster electronic bridge instruments; Flow meters—electric integrators; Thermoverters, power totalization; Series 500 recording gages and thermometers.

In Attendance: E. A. Merwin, Dist. Mgr. Houston; J. H. Ferguson, Dist. Mgr. St. Louis; Walter Messmer, H. W. Sakrison, Field Engrs.; W. H. Faeth, Exec. V.P. & Treas.; H. E. Beane, Gen. S.M.; F. W. Borchers, Ass't. S.M.; E. Nuber, Mgr. Application Eng'rg. Dept.; D. C. Sanford, W. E. Rufleth, E. L. Stilson, N. M. Blair, K. Peterson, Application Engrs.

Brookfield Engineering Laboratories, Inc.
Stoughton, Mass. 619

Exhibiting: New Products—Eight-speed viscometer with 200-to-1 ratio of speeds. Explosion-proof model of Brookfield viscometer. **Regular Products**—Synchro-lectric viscometer; Counter-rotating mixer. Special equipment for problems of viscosity measurement and control.

In Attendance: W. B. Brookfield, Pres. & S.M.; Richard A. Brookfield, V.P. Production; G. W. Brookfield.

Brush Development Co.
Cleveland 14, Ohio 302, 304

Exhibiting: New Products—BL 226 six-channel magnetic oscillograph, records a-c. or d-c. phenomena from 0 to 100 cps, individually positionable penmotors, three chart speeds; BL 954 high-gain preamplifier to extend measurements and recordings into low microvolt field in frequency range of 0.2 to 100 cps; BL 122 Faxfilm surface comparator for non-destructive examination and record of finish, grain, porosity, wear and texture. **Regular Products**—Amplifier; Universal bridge switch; Surface analyzer; Double-channel magnetic oscillograph; Uniformity analyzer; Universal analyzer; Beat-frequency oscillator; Single-channel magnetic oscillograph; Deviation test bridge; Heterodyne voltmeter; High-speed level recorder; Frequency-response tracer.

In Attendance: A. J. Novak, Mgr. Commercial Engrg. Inst. Div.; E. M. Hensley, W. R. Stern, Commercial Engrs., Inst. Div.

Buffalo Meter Co.
Buffalo 14, N. Y. 246

Exhibiting: Meters, liquid, volumetric type, for measurement of most liquids including water, oils, hot water, chemicals.

In Attendance: H. F. Barrett, S.M.; Wm. G. Carter, Ass't. S.M.; O. W. Muller, P. F. La Roche, M. O. Schultz, Houston Reps.

Burgess Battery Co.
Freeport, Ill. 441

Exhibiting: Dry batteries; Reserve batteries; Complete battery line; Special batteries for special applications; Battery engineering service.

In Attendance: L. D. Foust, Sales Engr.; R. E. Senter, Repr.

Century Geophysical Corp.
Tulsa, Okla. 310, 316

Exhibiting: Vibration-recording equipment, Oscillographs; Amplifiers; Galvanometers; Geophysical amplifiers; Oscillographs; Galvanometers.

In Attendance: Arnold Barnes, Alex Weiss, C. W. Miller, Sales Reps.; J. A. Stafford, Ch. Engr.; T. J. Ray, Jr., Sales Mgr.

Chemiquip Co.
New York 29, N. Y. 643

Exhibiting: New Products—Mercury receiver, stainless steel construction, built-in snubbing device dampens pulsations and surges in manometer and prevents loss of mercury from manometer into receiver at pressures under 25 psi. **Regular Products**—Porous metallic pressure snubbers.

In Attendance: Julian A. Lipman, Gen. Mgr.; Sylvia S. Lipman, Sec.

Cole Instrument Co.
Los Angeles 15, Calif. 336

Exhibiting: New Products—Graph follower and plotter for use with computing equipment; Electrostatic voltmeters; High-precision potentiometers for computers, transducers, guided missiles, etc.; Precision wire-wound Resistors for instrument multipliers, computers, precision amplifiers, etc.; Linear and non-linear resistor cards. **Regular Products**—Panel instruments; Switchboard instruments; Switchboard type shunts; Switchboard current transformers; Rotary tap switches; Precision decade resistance boxes; Portable instruments; Megohmmeters; A-c. and d-c. industrial analyzers; Phase sequence indicators; Aircraft electrical system tester; Large optical pointer type instruments; Pyrometers; Terminal lugs; Strain-gage indicators.

In Attendance: F. H. Cole, Owner; L. L. Morrison.

Commercial Iron Works
Los Angeles, Calif. 637

Exhibiting: Type CN orifice fittings; DPL Deadline orifice fittings; DSB Deadline orifice fittings.

In Attendance: I. G. Jenkins, Plant Supt.;

W. B. Rawson, V.P.; Geo. T. Moore, C. Karl Brown, W. H. Leverett, Sales Engrs.

Conoflow Corp.
Philadelphia 3, Pa. 126, 128

Exhibiting: New Products—Rotomotor, heavy-duty pneumatic operator for throttling control service, travels 24 in. thrust loads to 40000#; Ratio Relay, adjustable differential regulator, fixed differential regulator and various regulator items added to standard line. **Regular Products**—Control valves; Cylinders; Control panels (remote manual); Airpak; Cono purge; Pressure transmitter.

In Attendance: R. B. Werey, Pres.; J. C. Koch, V.P.; J. R. Simpson, J. B. Madison, Sales Engrs.; E. K. Graham, Jr.; Ch. Engr., S. R. Brown.

Consolidated Engineering Corp.
Pasadena 8, Calif. 225, 227, 229

Exhibiting: New Products—Micromanometer for accurate pressure measurement in the 0-150 micron range; Model 5-117 four-channel recording oscillograph for laboratory use, uses 70-mm. photographic paper in 100 ft. rolls; Pressure pickups, differential resistive type in a wide range of sensitivities from 10 psi to 250 psi; Model 8-108 strain-gage bridge balance, compact 8-channel permitting direct recording from resistance strain gage into sensitive galvanometer. **Regular Products**—Leak detector, Recording oscillographs, Pickups, Recording measurement systems. Analytical mass spectrometer service.

In Attendance: J. R. Bradburn, V.P.; H. F. Wiley, Dir. Tech. Services; R. L. Smallman, Dir. Tech. Services; Geo. H. West, Dir. Pub. Rel.; C. P. Spaulding, Elect. Engr.; W. B. Claus, Mech. Engr.; Rex L. Welch, R. H. Nelson, R. H. Riddle, G. H. Vaughan, H. W. Ruby, C. J. Underwood, Jr., J. F. Davidson, Field Engrs.

Continental Equipment Co.
Coraopolis, Pa. 419, 421

Exhibiting: Butterfly valves, manual- and power-operated.

In Attendance: Arthur M. Capper, Pres.; Charles A. Dally, Ass't. Ch. Engr.; Wm. F. Hartmann, Sales Dept.

Cook Electric Co.
Chicago 14, Ill. 102

Exhibiting: Pressure switches; Sealed units; Bellows devices; Aircraft components; Aneroids; Time delays and relays. Electrical and electronic research engineering and manufacture. Complete testing under Government specifications.

In Attendance: Ted M. Curtis, C. Flubacker.

Crosby Steam Gage & Valve Co.
Wrentham, Mass. 728

Exhibiting: New Products—Safety Relief Valves of balanced area design for elimination of back-pressure effects; Portable fluid pressure scale with motor drive for testing pressure gages. **Regular Products**—Safety and relief valves; Indicating and recording pressure and vacuum gages; Gage testing equipment and gage protectors. Repair service.

In Attendance: Wm. P. Husband, Jr., Pres.; J. J. Bresnahan, Gen. S.M.; J. Gieseke, Dist. S.M.; Clarence G. Albert, W. H. Curtin & Co., Reps.

Daniel Orifice Fitting Co.
Houston 20, Texas 232, 234

Exhibiting: New Products—Stainless steel "O" ring instrument needle valve; Simplex orifice plate holder; Liquid and gas scrubbers; Custom-made orifice meter manifold. **Regular Products**—Orifice fittings and fabricated meter runs, Instrument seal pots; Controlled check valves; Orifice plates; Meter levelling saddles, Thermometer wells.

In Attendance: J. Holdenried, V.P., W. A. Griffin, V.P.; John Whalen, Ch. Engr.; Virgil Moore, Engr.; F. N. Davis, P. M. Vickery, C. O. Cox, J. B. Corzette, G. W. Daniel, P. Pirkle, Sales.

Davis Instruments Div., Davis Emergency Equipment Co.
Newark 4, N. J. 244

Exhibiting: New Products—Continuous indicating and recording 4-point tube sampling combustible gas analyzer operating on new thermocouple filament principle; Continuous indicating or recording oxygen analyzer operating on new thermocouple filament principle, scale range 0-5%; Electro-conductivity recording analyzer for very low concentrations (P.P.M.) of chlorinated hydrocarbons, SO_2, chlorine, etc., in air. **Regular Products**—Portable and continuous gas analysis instruments. Design and manufacture of gas analysis and process control instrumentation.

In Attendance: F. Rutledge Davis, Pres.; F. Taylor, Jr., Gen. Mgr.; A. E. Lawson, Jr., Chief Engr.

De Zurik Shower Co.
Sartell, Minn. 130

Exhibiting: De Zurik Valves, hand and automatically operated.

In Attendance: David De Zurik, Pres.; Reps. of distributor organization.

Edin Co.
Worcester 8, Mass. 217

Exhibiting: Magnetic oscillograph galvanometers; Magnetic oscillographs; Oscillograph amplifier; D-c. amplifier; High-gain amplifier.

In Attendance: Steven Bilowich, S.M.; Frank E. Wing, Jr., Salesman; Neil R. Seitzman, Sales Engineer; Murray W. Edinburg, Pres.

Eggelhof Engineers
Houston, Texas 417

Exhibiting: Products of Fulton Sylphon Div.; Magnetrol, Inc.; Kieley & Mueller, Inc.; Continental Equipment Co.

In Attendance: Bob Molnari, Mgr.; Claude Cullinane, Chip Chapman, Leonard Meyer, Sales Engr.

The Electric Auto-Lite Co. Instrument & Gauge Div.
Toledo 1, Ohio 617

Exhibiting: Recording thermometers; recording pressure gages; Compound recording gages; Dial-indicating distant-reading thermometers.

In Attendance: L. B. Murphy, S.M.; R. R. Hopkins, Sales Rep.

Fenwal, Inc.
Ashland, Mass. 206

Exhibiting: Thermoswitch thermostats; Detect-A-Fire detectors; Temperature control engineering.

In Attendance: J. M. Storkerson, V.P. & G.M.; C. J. Robinson, S.M.; E. V. Hawkins, Western Branch Mgr.; C. T. Grosswendt, Sales Engr.; H. G. Hall, D. Driscoll, Sales Engrs., Paul King Co.

Fischer & Porter Co.
Hatboro, Pa. 612

Exhibiting: New Products—V/A Cell, pneumatic flow transmitter operated from kinetic manometer to produce linear relation between output pressure and flow rate; Mercury manometer using magnetic coupling to replace conventional packing gland or pressure-tight bearing. **Regular Products**—Flowrator meters, indicators, recorders, controllers, totalizers and proportioners for flow; Process control instruments for liquid level, specific gravity, viscosity, temperature, pressure.

In Attendance: R. W. Fritzsche, Regional Mgr.; J. W. Simpson, G. Dor Hinger, W. J. Durkin, J. W. Knoblock, J. B. Carver, P. A. Puleo, Dist. Engrs.

Fisher Governor Co.
Marshalltown, Iowa 523, 525, 527

Exhibiting: New Products—Liquid level controller pilot, single-seated, "Q" reversible body construction, soft disk body assembly utilizing "O" ring as seating disks; Fabricated Level-Trol cage; Type 63 single-seated pilot-operated gas pressure regulator, heavy-duty single seated AA angle body construction, continuously-connected handwheel topwork. **Regular Products**—Diaphragm-motor valves; Liquid level controllers; Self-contained pressure regulators; Teflon packing; Pressure intermitters; Pressure balanced topwork; Inner valve exhibit; Pilot-operated pressure regulators.

In Attendance: P. A. Elfers, V.P.; R. A. Engle, V.P.; J. W. Fisher, V.P.; G. F. Brockett, Ch. Engr.; L. E. Eige Ass't. S.M.; Hugh Hale, Harold Kinney, Robert Read, Sales Engrgs.; Kenneth Puffer, C. E. Sweiven, Jake Eige, Shelby Ross, Jim Fraychinaud, Jim Spurloch, Puffer-Sweiven Co.

Foster Engineering Co.
Union, N. J. 440

Exhibiting: "Flow Tube," a new primary differential-pressure producer for the measurement, regulation and control of fluid flow.

In Attendance: H. J. Fortier, V.P.; Vincent Gentile, Jr., Ch. Engr. Flow Tube Div.; Dean Ault, William Small, Reps.

Foxboro Co.
Foxboro, Mass. 125, 127, 129

Exhibiting: New Products—Flow meters featuring unequalled freedom from friction in new bearings; U-bend with efficient damping-drain plug assembly, streamlined float-and-lever; Poweractor cylinder positioner, receives pressure signal 3-15 psi. and applies up to 150 psi.; Stabiload cylinder valve operator, features extremely low friction and virtual elimination of air leakage; Capacity Dynalog for indicating, recording or controlling electrical capacitance, self-balancing, panel-mounted; Volume booster, faster valve operation, amplifies air volume, keeps 1:1 ratio between input and output pressures; Type 20 pressure regulator, gives greater sensitivity and reduces "droop" in controlled pressure at both low and high flows; Consotrol controller, for use with graphic and console panels; Instruments for graphic and console panels, first showing of new indicating, recording and controlling instruments designed for use in console and graphic panels. **Regular Products**—Resistance, emf. and multi-record Dynalogs; d/p (differential pressure) cells—3A, 5A, EL; Model 40 controller.

In Attendance: C. E. Sullivan, V.P. & Gen. S.M.; H. O. Ehrisman, Ass't. Gen. S.M.; V. V. Tivy, R. Milham, R. Hosmer, J. G. Dobson, J. J. Burnett, J. J. Connelly, E. L. Stark, L. W. Parten, J. B. Deaderick, W. A. Rock, A. H. Shafer, E. E. Kleir.

Fulton Sylphon Div., Robertshaw-Fulton Controls Co.
Knoxville 4, Tenn. 318, 320, 322

Exhibiting: Temperature controllers; Packless valves; Bellows and bellows assemblies.

In Attendance: E. D. Rogers, Adv. Mgr.; L. S. Dysart, Ass't. Sales Mgr., Controls Div.; D. D. Gordon, Applications Engr.; Reps. of Eggelhof Engineers, Inc.

General Electric Co.
Schnectady 5, N. Y., 201, 203, 205 207

Exhibiting: New Products—Resistance thermometer (Types HP-11-12-13-14) for indicating and controlling temperatures in the minus 100 to plus 1800 F range, protector form also available, accuracy of 3.4 of 1% of full scale, controller sensitivity 0.1 of 1% of full scale. Hand Pyrometers (Type FH-1) dual scale range (0-500 F to 0-1500 F), automatic cold-junction compensation to 3½" scale, tips interchangeable without recalibration. **Regular Products**—Thermocouple pyrometer (Types HP-1, 2, 3, 4); Thermocouple wire; Oscillograph (Type PM-18); Photoelectric recorder; Photovoltaic cells; Thermowatts and power factor; Radiation monitor; Light-beam vibration indicator; Gausmeter; Hand tachometer; Mass spectrometer; Mercury vapor detector; Type H leak detector; Scintillation counter for alpha, beta, gamma radiation; Boron-coated neutron counter tube, Portable radiation probe.

In Attendance: N. Gildersleeve, In Charge Process and Industrial Instruments, Electric Instrument Sales Div., Meter and Instrument Divs.; H. W. Kuhn, G. W. Engler, Electric Inst. Sales Div., Meter & Inst. Divs., E. T. Connor, R. M. Ilfeld, Laboratory Prod. Sales Div., Special Prods Divs.; Dr. J. G. Hutton, Sections Engr., Neucleonics & High-voltage Instruments, Gen. Engrg. & Consulting Lab.; R. A. Winter, Exhibit Supervisor, Adv. & Sales Pro. Divs.

General Precision Laboratory
Pleasantville, N. Y. 631

Exhibiting: New Products—Industrial television camera chain of a radically new design, small, compact, light weight, high quality picture pick up tube; Precision adjustable voltage reference; Pressure measuring catheter; microwave components. **Regular Products**—Ultrasonic generators; Ultrasonic oscillators.

In Attendance: Hoyt A. Stearns; Blair Foulds; John M. Sims.

G. M. Giannini & Co.
Springfield, N. J. 501, 503

Exhibiting: New Products—Pressure transmitters providing accurate electrical signals that do not require amplification for industrial recorders, servos or remote indication of pressures of corrosive or non-corrosive gases or liquids; Functional and linear precision potentiometers, synchro type of mounting. **Regular Products**—Telemetering transmitters for measurement of pressures, temperatures, accelerations and position; Gyros; Microtorque potentiometers; Rectilinear potentiometers; Control systems; Pressure switches; Functional and linear precision potentiometers, Adaptation of Microtorque potentiometers to standard industrial indicating gages to provide an electrical signal for recording or remote indication.

In Attendance: G. M. Giannini, Pres.; C. H. Colvin, V.P.; R. P. Luce, Jr. Eastern S.M.; A. C. Hughes, Western S.M.; H. T. Brierley, W. I. Shevell, E. R. Davis, E. C. Hokanson, L. M. Ryan, Field Engineers.

Gotham Div. American Machine and Metals Inc.
New York 12, N. Y. 718, 720

Exhibiting: New Products—Gas Lift Timer for quick and easy adjustment of inspected controlled air or gas pressure into oil wells on varying time basis. **Regular Products**—Pneumatic transmitter and receiver; Recorders; Controllers; Dial thermometers.

In Attendance: Walter J. Halpern, Gen. Mgr.; Robert Hamerschlag, S.M.; Charles Halpern, West Coast; Joe P. Dillard, Agent, J. H. Stephenson, Agent.

Gow Mac Instrument Co.
Newark 5, N. J. 308

Exhibiting: New Products—Gas Watchman, sensing elements for atmospheres in closed spaces, bell jars, etc.; 3-pass Cell, six-filament gas cell for use with two samples and one reference gas simultaneously; 30-S Cell, fast-acting bare-wire filaments in low-volume cavities; P-Kem Special, assortment of 3 T/C sensing

elements plus current-control unit with milliammeter; **Fuel-gas Master**, portable tester for H_2, inert ratios, natural gas, city gas mixtures, precombustion (air gas) mixtures; **Power-Pack**, portable 115V 60-cycle unit for close regulation. **Regular Products**—Low-cost gas analysis apparatus, thermal conductivity type.

In Attendance: James L. McFadden, Pres.

Grove Regulator Co.
Oakland 8, Calif., Houston 4, Texas 338

Exhibiting: New Products—PB-300 Regulator, Grove Poweractor dome principle applied to high-pressure regulator for pressure reducing or back pressure service; T Series seat-seal valve, incorporates "O" ring as sealing member; Model 80-896 pressure-reducing regulator. **Regular Products**—Flexflo valves; Chexflo check valves; Mitty-Mite regulators; Small-volume high-pressure regulators; Solenoid operators; Relievers.

In Attendance: C. B. Truitt, Southwestern Div. S.M.; E. H. McMenemy; J. D. Hicks; L. S. Robb; J. A. Records.

Hagan Corp.
Pittsburgh 30, Pa. 219, 221

Exhibiting: New Products—FRB Transmitter utilizing speed and accuracy of ring balance meter element and Hagan pilot valve to produce pneumatic signals proportional to differential Receiving regulator, pneumatically-operated power unit for accurate control of heavy dampers or valves. **Regular Products**—Flow signal transmitter, high pressure type; Ring balance meters; Low-head differential transformer.

In Attendance: D. J. Erikson, Pres.; M. J. Boho, V. P. Sales; O. B. Vetter, Ch. Engr. Ring Balance Div.; M. S. Gare, Mgr. Ring Balance Div.; C. W. Work, Mgr. Sales Pro.

Hammel-Dahl Co.
Providence 3, R. I. 425, 427

Exhibiting: New Products—New design of all steel superstructure of valves. **Regular Products**—Complete line of automatic control valves in all sizes and all materials, engineered for temperature, pressure, flow, liquid level and other continuous control applications.

In Attendance: E. T. Dahl, Pres.; Maurice Mac Donald, V.P.; John O. Tragard, V.P.; David Golner, Ass't. Engr.; John Curran, Design Engr.; Robert Carter, Application Engr.; Otto Kneisel, Development Engr.; Harold Miller, Wayne Farley, John E. Charsha, Jr.; District Mgrs.

Hankison Corp.
Pittsburgh 33, Pa. 409

Exhibiting: Condensifilter for cleaning and dehydrating instrument air; Recirculator. Maintenance Service.

In Attendance: P. M. Hankison, Pres.; D. K. Bice, S.M.

Hays Corp.
Michigan City, Ind. 245

Exhibiting: Veriflow meter; Oxygen recorder; CO_2 recorders (both water and electronically operated); Series B, D, FOT, OT and V draft and low-pressure instruments; Combustion control; Orsat gas analyzer.

In Attendance: Wm. H. Pugsley, V.P. Field Research; Orval Riggs, Mgr. Application Engrg.; Phil Sprague, Jr., V.P. & Adv. Mgr.; Power Specialty Co., Reps.

Heiland Research Corp.
Denver 9, Colorado 627, 629

Exhibiting: New Products—800-1 Strain amplifier, very small single-channel unit utilizing an interchangeable battery or 110-volt 60-cycle power supply; Micro-barometer, precision aneroid relying on optical rather than mechanical amplification of a Bourdon helix tube; Microbarograph, utilizes micro-barometer with a differential photoelectric cell pickup recording directly on pen type recorder. **Regular Products**—A401R-6, 6-channel portable oscillograph recorder; A500R-12, 12-channel portable oscillograph recorder; A708-24, 24-channel automatic oscillograph recorder; A712-36, 36-channel automatic oscillograph recorder; A718-60, 60-channel automatic oscillograph recorder; Askania magnetometer; Askania variation recorder; R-3 resistance gradiometer.

In Attendance: C. A. Heiland, Pres.; Donald B. Clow, Mgr. Ind. Sales; W. A. Brown, Russell M. Coldwell, G. Curtis Engel, James L. Kearns, Gerald B. Miller, Hugh W. Marsland, M. P. Odell, H. M. Richardson, J. Y. Schoonmaker, Benjamin Woodman, Russell Young, Engineering Reps.

Helicoid Gage Div.
American Chain & Cable Co.
Bridgeport 2, Conn. 446

Exhibiting: New Products—Air pressure transmitter for flush, wall or stem mounting, actuated solely by Bourdon tubes, for pressure ranges from 10 to 10000 psi. **Regular Products**—Helicoid pressure gages.

In Attendance: Joseph V. Tracy, S.M.; Ernest H. Grauel, Ch. Engr.

Hills McCanna Co.
Chicago 18, Ill. 208

Exhibiting: New Products—Type U metering pump with manual adjustments while in operation. **Regular Products**—Diaphragm valves, throttling and positioned control; Lubricators, magnesium castings; "K" hydraulic drive positioner control metering pump.

In Attendance: C. A. Howe, Pres.; F. R. Grassle, Supt.; R. M. McFarland, Tech. Supervisor; Ed Soph, Houston Rep.; R. T. Kidde, Adv. and P. Pro. Mgr.

Houston Slush Pump Repair Co.
Houston, Texas 439

Exhibiting: Hildebrandts Mighty Midget recording pressure gage, compact, rugged, portable pressure recorder for heavy-duty field service. Reconditioning and repair service for all types pressure and temperature indicators, recorders and controllers.

In Attendance: J. P. Hildebrandt, Sec. Treas. and Managing Engr.; J. B. McCormick, Shop Foreman; L. A. Parks, Field Salesman, Van Canton, Instrument Mechanic; Paul Pancherz, Instrument Mechanic.

Illinois Testing Laboratories, Inc.
Chicago 10, Ill. 742

Exhibiting: New Products—Alnor Pyrotac, excess temperature cut-off and alarm, non-electronic and moderately-priced. **Regular Products**—Pyrometers; Velometers, air velocity; Resistance thermometers.

In Attendance: W. J. Bailey, Sales Mgr.; J. A. Obermaier, Pres.; James Roe, Raymond Tate, Sales Reps.

Imperial Brass Manufacturing Co.
Chicago 7, Ill. 429

Exhibiting: Tube working tools (tube cutters, flaring tools, tube benders, swedging tools, reamers); Tube fittings (Hi-Duty, flex, compression, flared, inverted flared, steel flareless); Shut-off valves; Drain cocks.

In Attendance: Frank McNellis, Jr., V.P.; C. H. Benson, V.P.; Harry Pearson, Rep.

Industrial Electronics, Inc.
Detroit 10, Mich. 443

Exhibiting: New Products—Miniature accelerometers for all ranges and natural frequencies; Gage heads, standard and custom-built employing a linear variable differential transformer as the sensing element; Control box, balancing network for use with Uni-Bridge, Cali-Bridge, or Dyna-Myke using either SR-4 strain gages or LVDT's; Selector switch, control as many as ten channels with one selector switch, ten control boxes, and one Uni-Bridge, Cali-Bridge, or Dyna-Myke. **Regular Products**—Model 129-B Dyna-Mike; Model 144 Dyna-Meter; Model 128 Uni-Bridge; Model 134 Cali-Bridge; Model 132 Cali-Power AC; Model 145 Cali-Power DC.

In Attendance: J. W. Head, Pres.; W. T. Bean, Jr., Director.

Industrial Equipment Co. of Houston
Houston 11, Texas 730

Exhibiting: New Products—Automatic loading rack controls (Mercoid Corp.); Pipe line protective panel controls (Mercoid Corp.); System for automatic operation of flowing oil wells. **Regular Products**—Liquid level controls for sewage and water works; A-c. and d-c. motor control; solenoid and Hydramotor operated valves; Synchronous motors; Generators; Capacitors; Switchboards; Liquid level controls for all liquids; Single-phase motors; Pressure and temperature controls; Oil-immersed motor controls; Instrument transformers; Controls for internal combustion engines; Squirrel-cage motors; Flexible couplings; Brass fittings; Ermetosteel and stainless steel.

In Attendance: E. F. Meyer, V.P.; J. E. Brown, Pres.; R. A. Roberts, H. F. Plackemeier, Salesmen.

Industrial Instrument Corp.
Odessa, Texas 732, 734

Exhibiting: New Products—IIC non-freezing bearing, frictionless bearings, for instruments, does not require lubrication. **Regular Products**—IIC orifice plates; Orifice well tester; Orifice flow prover; Seal systems; Rochester thermometers.

In Attendance: W. M. Reese, Pres.; W. M. Reese, Jr.; John W. Cloud; Joe E. Kilchrist; Ralph Foster, Rochester Thermometer.

Industrial Pyrometer & Supply Co.
Alton, Ill. 238, 240

Exhibiting: Insulated thermocouple lead wire; Thermocouples; Thermocouple heads; Protection tubes; Wires; Insulators.

In Attendance: A. L. Hack, Pres.; F. L. Hack, Gen. Mgr. A. J. McBride, Special Rep.

Industrol Corp.
Roselle Park, N. J. 416

Exhibiting: New Products—Gas sample driers, completely automatic, electrically-regenerated, explosion-proof. **Regular Products**—Dynamic dehumidifiers for instrument air; Centrisorb air filters; Continuous drainers.

In Attendance: George R. Feeley, Pres.; James V. Mannion, V.P. Engrg.; Robert C. Axt, Sales Engr.

Institute of Radio Engineers
New York 18, N. Y. .....M. C.*

Exhibiting: Featuring IRE Professional Group on Instrumentation, its officers, members, papers published and its relationship to the IRE and to the industry; "Proceedings of the IRE"; "IRE 1951 Directory"; "IRE Standards"; Membership pins; Literature and applications, IRE membership.

In Attendance: Wm. C. Copp, Adv. Mgr. IRE; Mrs. Wm. C. Copp, Ass't on Information; Dr. Wm. M. Rust, Regional Director IRE; G. K. Miller, Chairman, Houston Section IRE; S. A. Martin, Houston Committee IRE-ISA.

Instrument Society of America
Pittsburgh 12, Pa. .....M. C.*

Exhibiting: Publications of ISA, recommended practices, ISA Journal, preprints and technical papers; Services to ISA Members; Society information and literature; ISA pins.

In Attendance: ISA National Officers, members of the Houston Section ISA.

Instruments Publishing Co.
Pittsburgh 12, Pa. 210

Exhibiting: "The Handbook of Measurement and Control," a just-published informative digest of the new science of Instrumentation; **Instruments** The magazine of Measurement and Control; **The Instruments Index**, the bi-annual directory of the Instrument Industry; **The Instrument Maker**, the trade journal of the Instrument Industry; **The Instrument Maker Guide**, the bi-annual directory of the Parts Manufacturers for the Instrument Industry. Books: "Applications of Industrial pH Control" by Allen L. Chaplin; "A Romance in Research—The Life of C. F. Burgess" by A. McQueen; "Elementary Engineering Electronics" by Andrew W. Kramer; "The Engine Indicator—Its Design, Theory and Special Applications" by K. J. DeJuhasz; "Heat Inertia in Problems of Automatic Control of Temperature" by Victor Broida; "Instrumentation and Plant Design" by F. Trapnell; "Operation and Care of Circular-scale Instruments" by James Spencer; "Requirements for an Instrument Department" by Wm. H. Fortney; "Scientific and Industrial Glass Blowing and Laboratory Techniques" by William E. Barr and Victor J. Anhorn; "Instrumentation for the Process Industries" (symposium); "Maintenance and Servicing of Electrical Instruments" by James Spencer; "Mechanical Measurements by Electrical Methods" by H. C. Roberts.

In Attendance: Richard Rimbach, Publisher; M. F. Behar, Editor; M. H. Aronson, Managing Editor; Richard J. Rimbach, N. Y. Mgr.; W. J. Gallagher, Phila. Mgr.; H. W. Haskett, Chicago Mgr.; S. E. Wright, St. Louis Mgr.; M. D. Pugh, Calif. Mgr.; C. F. Goldcamp, Pittsburgh Mgr.

Jarrell-Ash Co.
Boston 16, Mass. 625

Exhibiting: New Products—JACO recording microphotometer, extremely fast recorder having a projection comparator feature; Calculating board, automatically plots emulsion characteristic curves providing rapid and continuous check on gamma and development conditions, reads directly in terms of percentage of constituent; Combination spectrograph and plate viewer, can be supplied with measuring x-ray scale and cursor for use with x-ray diffraction equipment; Hilger Raman spectrograph, employs two cameras, one F4.4 and one F1.5, supplied with quartz and glass optics. **Regular Products**—Hilger large quartz spectrograph.

In Attendance: R. E. Ashley, Gen. S. M.; L. O. Eikrem, Tech. S. M.; F. Breck, Research Dir.

Jerguson Gage & Valve Co.
Sommerville 45, Mass. 231

Exhibiting: New Products—Explosion-proof illuminators (Underwriter approved) for gages, Rotameters, etc.; Non-frosting gages; Multi-service angle globe valves up to 3/4 in. for instrument service. **Regular Products**—Liquid level gages and valves; Truscale remote-reading gage.

In Attendance: James A. Ford, V.P.; E. E. van Ham, V.P.; W. A. Griffin, Sales Rep.

Kieley and Mueller, Inc.
North Bergen, N. J. 418, 420

Exhibiting: Control valves and automatic regulators.

In Attendance: Joseph O'Connor, Pres.; Robert J. Donnelly, S.M.; Ward K. Stallings, Ch. Engr.; Norman Lieblich, Sales Engr.

Lapp Insulator Co.
Le Roy, N. Y. 309

Exhibiting: Pulsafeeder metering pumps; Auto-Pneumatic Pulsafeeder metering pumps. Both for treating, sampling, blending, diluting

*Members' Center

and proportioning fluids. Both adaptable to conventional pneumatic instrumentation.

In Attendance: Lawrence F. Wilson, Mgr. Pulsafeeder Div.; Victor Leipold, Service Engr.; Oke Muller, Paul LaRoche, Wm. Shultz, Texas Reps.

Leeds & Northrup Co.
Philadelphia 44, Pa. 422, 424

Exhibiting: Speedomax pneumatic temperature controller; Speedomax pH recorder; Speedomax X-Y recorder; Speedomax electrolytic conductivity recorder; Speedomax 48-point temperature indicator; Plastic- constructed immersion and flow-type pH cells; Portable millivolt and temperature indicators; Thermocouples; Resistance thermometer elements; D-c. micromicroampere amplifier; Speedomax double-pen recorder.

In Attendance: Philadelphia—A. E. Tarr, Mgr. Sales Engrg. Div.; L. E. Emerich, Mgr. Market Dev. Div.; J. L. Serrill, E. B. Estabrook, Field Engrs. Chicago—N. Cohn, Mid-West Reg. Mgr. Houston—R. E. Hansen, Dist. Mgr.; D. S. Lansdon, Jr., J. W. Stockard, C. G. Weaver, Field Engrs. Tulsa—M. E. Griffith, Dist. Mgr.; R. R. Studemund, Field Engr.

Leslie Co.
Lyndhurst, N. J. 714, 716

Exhibiting: New Products—Liquid level controller for maintaining levels in closed or open vessels without use of floats. **Regular Products**—Reducing valves; Pump governors; Temperature and pressure controllers; Air horns and steam whistles; Strainers.

In Attendance: R. W. Boettiger, S.M.; John S. Leslie, Pres.; A. J. Dromm, Sales Engr.; G. R. Hetherington, S. M., Gulf Eng'rg. Co.

Librascope, Inc.
Glendale, Calif. 106, 108

Exhibiting: New Products—Computer controls.

In Attendance: E. W. Silvertooth.

Earl Lipscomb Associates
Dallas 5, Texas 638, 640, 642

Exhibiting: Electrical and electronic testing, measuring, regulating and recording instruments of the following:

James G. Biddle Co.—Megger ground, insulation, conductivity meters, speed indicating, transformer and cable testing, slide wire resistors; Allen B. Du Mont Labs.—Cathode-ray tubes and instruments, auxiliary apparatus; Gertsch Products—VHF frequency meters, filters; Hewlett-Packard Co.—Audio oscillators and signal generators, vacuum-tube voltmeters, VHF & UHF equipment, wave and distortion analyzers, frequency standards, electronic frequency meters, FH monitors, amplifiers, attenuators, regulated power supplies; Nuclear Inst. & Chem. Corp.—Insts. for nuclear measurement; Sanborn Co.—Direct-recording oscillographs and amplifiers; Sorenson & Co.—Electronically controlled voltage regulators and regulated power supplies; Varian Assocs.—Klystron oscillators, nuclear induction instruments.

In Attendance: Earl W. Lipscomb, Robert M. Shuffler, Edward G. Holmes of Earl Lipscomb Assocs.; Robert Brunner, Hewlett-Packard; Elmer Gertsch, Leonard S. Cutler, Gertsch Products.

J. E. Lonergan Co.
Philadelphia 6, Pa. 735

Exhibiting: New Products—Pressure transmission system for use in connection with remote indicating or recording gages; Improved receiver gages in the low-pressure range; Remote liquid-level indicator; Back-pressure-balanced safety valve for refinery service. **Regular Products**—Ported disk nozzle type safety and relief valves; all-stainless-steel relief valves; Combination pressure-vacuum relief valves; Pilot-assisted quick-opening valves; Bourdon-tube, diaphragm, and bellows-actuated pressure gages; Air and steam whistles.

In Attendance: A. L. Diederich, Jr.; T. J. Mandes; O. W. Muller; Paul LaRoche; M. W. Schultz.

Lord Manufacturing Co.
Erie 6, Pa. 341

Exhibiting: New Products—Temproof all-weather equipment mountings for aircraft and industrial use; Base mounted racks for radio and electronic equipment; Silicone and Silastic vibration control mounts for extreme high and low temperature locations; "Z" type bonded rubber mounts for light-weight instruments and equipment in minimum installation space. **Regular Products**—Bonded rubber plate forms; Tube-form and special vibration isolation mounting; Idler wheels; Multiplane mounts; Bonded rubber diaphragms; Tube socket vibration isolators; Bonded rubber flexible drive couplings; Signal Corps type shock mounts for mobile electronic equipment; Radiofocal rack mounts; Special bonded rubber mechanical parts.

In Attendance: Geo. E. Tubb, Gen. Sales Mgr.; Bruce O. Todd, Field Engr. S. W. Territory; Phillip Woodford, Prod. & Sales Engr.; Geo. E. Behlmer, Field Engr.

Magnetrol, Inc.
Chicago 23, Ill. 415

Exhibiting: New Products—Model TF-62 side mounting tank float switch for higher pressures and lower specific gravity of liquids; Demonstrator model showing elimination of effects of vibration; F-501 flow switch for oil field use; Model A-100-F tank float switch, operating model. **Regular Products**—Liquid level controllers, top-mounting, side mounting and external float cage types. Consulting service.

In Attendance: Lester E. Stybr, S.M.; B. L. Binford, Ch. Engr.; Reps. of Industrial Equip. Co. of Houston and Eggelhof Engineers.

Manning, Maxwell & Moore, Inc.
Stratford, Conn. 305, 307

Exhibiting: New Products—American bimetal dial thermometers, 3 1/2 in. and 5 in. dial sizes, ranges 60 F. to 1000 F., accurate within 1% of scale range, hermetically sealed; Hancock 150# and 200# bronze globe and angle valves with 500 Brinell stainless steel seats and disks; Hancock 150# bronze Flocontrol valve with 500 Brinell stainless steel seat and disk. **Regular Products**—Ashcroft gages; American industrial instruments; Consolidated safety and relief valves; Hancock globe, angle and gate valves.

In Attendance: A. W. Coleman, Gen. S.M.; J. F. Higgins, Adv. Mgr.; W. H. Bolin, S. M. Gauge & Inst.; C. F. Johnson, S.M. Valves; E. M. Dederer, Prod. S.M. Gauges; E. F. Nordstrom, Prod. S.M. Insts.; L. P. Stillman, Prod. S.M. Safety Relief Valves; G. M. Theimer, Dist. S. M.; R. J. Birkmeyer, Distributor S.M. Gauge & Inst.; C. H. Sugden, Ch. Engr. Gauges & Insts.; C. G. Roper, Ch. Engr. Elect. Insts.; R. Beck, Ch. Engr. Mech. Insts.; R. L. Springfield; R. M. Nicholson, Salesmen, Gauges & Instruments.

Marine and Industrial Products Co.
Philadelphia 4, Pa. 645

Exhibiting: New Products—Enlarged line of stainless steel safety and relief valves. **Regular Products**—Safety valves; Relief valves; Vacuum valves; Pump by-pass valves; Throttle valves; Stainless steel specialties, all for steam, water, air, gas, oil and all types of chemicals, for use on boilers, pipe lines, process vessels of all types.

In Attendance: Joseph Schubert, Pres.; Joseph F. Petrosius, Ass't. Ch. Engr.

Mason-Neilan Regulator Co.
Boston 24, Mass. 214, 216

Exhibiting: New Products—New design reduced-area trim and single-seated valve bodies; High pressure valve design; high-pressure level controller design; Safety shut-off gas valves; Side-mounted handwheel operators. **Regular Products**—Diaphragm-motor valves; Level controllers; Pressure regulators; Pressure balanced valves; Pressure instruments; Valve positioners.

In Attendance: F. Kenneth Morrison, V.P.; Ralph A. Rockwell, Dir. Engrg.; Paul Wing, Jr., Ass't. Dir. Engrg.; Eric A Bianchi, Mgr., Appln. and Sales Eng'rg.; Carl W. Gram, Mgr. New York; Henry C. Earle, Jr., Mgr. Calif; A. Blair Powell, Mgr. Pgh.; Gordon R. Thompson, Mgr. Chicago; C. W. Wood, Mgr. Phila.; John W. Robins, Mgr. Inst. Dev. Dept.; D. J. Condit, Pres. Condit Co., Tulsa; W. B. Rawson, V. P. Maintenance Eng'rg. Corp. Houston; R. E. Houlihan, W. L. Rairigh, W. H. Leverett, George Moore, Sales Reps. Maintenance Eng'rg. Corp. Houston.

McAlear Mfg. Co.
Chicago 8, Ill. 736, 738

Exhibiting: New Products—Pneumatic transmitter applicable for temperature, rate of flow, pressure, level and density measurement and control systems. **Regular Products**—Diaphragm-motor valves; Regulators and other specialties.

In Attendance: Wm. Ludvik, J. P. Henderson, G. F. Cook, J. C. Gall, C. J. Lohrey, W. Skoropad.

Measurements Corp.
Boonton, N. J. 104

Exhibiting: New Products—Model 31 intermodulation meter, completely self-contained; Model 111 crystal calibrator for calibration and frequency-checking of signal generators transmitters, grid dip meters, etc. requiring high degree of frequency accuracy. **Regular Products**—Standard signal generators; Square-wave generators; Pulse generators; Television signal generators; UHF radio noise and field strength meters; Megohm meters; Peak voltmeters; R. F. attenuators; Megacycle meters; Vacuum-tube voltmeters; Special test instruments. Design, development and production of electronic test instruments.

In Attendance: Jerry B. Minter, Ch. Engr.; Nelson C. Doland, Jr., S.M.

Meriam Instrument Co.
Cleveland 2, Ohio 136, 138

Exhibiting: New Products—Automatic manometer pressurizing system for measurement of high range pressures; New and improved manometers for measurement of pressures, vacuums and differentials. **Regular Products**—Manometers; draft gages; Mercury pressure gages, Tank liquid level gages; indicating flow meters.

In Attendance: J. B. Meriam, Jr., Pres.; A. A. Hejduk, V. P.; Mark Meriam, Sales Engr.

Metal Goods Corp.
St. Louis 15, Mo. 729, 731

Exhibiting: Tube fittings—Brass, steel, aluminum, stainless steel; Tube working tools; Gage snubbers; Tubing—aluminum, copper, stainless steel; Valves; Aluminum jacketing.

In Attendance: T. G. Rankin, S.M.; H. T. Gregg, V. P. & Dist. Mgr.; J. G. Meek, R. G. Goft, C. G. Gribble, J. A. Mabry, P. Vidovick, J. E. Shelton, R. W. Downs, Salesmen.

Metrotype Corp.
Chicago 20, Illinois. 740

Exhibiting: New Products—Radar type fault locator for power and telephone line, range from 0.1 to 150 miles on overhead lines, 0.1 to 25 miles on cable, line matching provided, range step, calibration circuits, and counter provide high accuracy. **Regular Products**—System of numerical recording and telemetering. Custom built electric equip.

In Attendance: George E. Foster, Pres.; Emil Evancich, Engr.

Mine Safety Appliances Co.
Pittsburgh 8, Pa. 301, 303

Exhibiting: New Products—Lira infrared gas and liquid analyzer, improved model for analysis and measurement of toxic concentrations of gas and liquids. **Regular Products**—Explosimeter; Combustible gas alarm, indicator and analyzer; CO tester and indicator; Hydrogen sulphide detector; Benzol indicator.

In Attendance: N. W. Hartz, Inst. Line Mgr.; J. P. Sherwin, J. E. Gray, Inst. Sales; G. T. Henderson, Inst. Serviceman; H. W. Richards, Dist. Mgr.; G. J. Gruber, Sales Engr.

Minneapolis-Honeywell Regulator Co.
Industrial Div.
Philadelphia 44, Pa. .....
..... 331, 333, 335, 337, 339

Exhibiting: New Products—ElectroniK function plotter, pen and chart drive mechanism, each actuated by independent measuring systems, records relationship of two variables each a function of the other; Duplex ElectroniK recorder, two-pen strip-chart instrument measuring two independent variables; Differential converter, mercuryless type manometer designed to provide control within narrow limits and to answer difficult installation and maintenance problems; Linear flow meters, new line of accounting type meters, evenly-graduated charts and scales adaptable to both mechanical and electrical forms; Electronic flow integrator consisting of scanning unit, electronic detector relay, and motor-driven 6-digit counter assembly. **Regular Products**—Compact indicating controller and Tel-O-Set units for color graphic panels; Electro-O-Pulse and Electro-O-Line relays; Honeywell valve products; Honeywell industrial controls; Micro Switch Div. products.

In Attendance: J. H. Binger, Gen. Mgr., Valve Div.; J. G. Booth, Supervisor, Mech. Inst. Div.; D. M. Considine, Mgr. Market Extension Div.; A. Day, Sales Engr.; I. K. Farley, Ind. Mgr.; J. J. Frantz, Sales Engr.; L. Gess, Chief of Prod. Application Engrg.; W. L. Hendricksen, Sales Engr.; K. R. Knoblauch, Sales Mgr. Valve Div.; A. E. Krogh, Mgr. Prod Application Engrg.; R. L. Mallory, Reg. Ind. Mgr.; L. M. Morley, V. P. & Gen Sales Mgr.; G. M. Muschamp, V. P. Charge Engr.; A. O. Pearson, Ass't. to Valve Div. S.M.; J. A. Robinson, Reg. Sales Mgr.; W. T. Rockhill, Exhibit Mgr.; R. A. Schlegel, Ind. Mgr.; H. M. Schmitt Ind. Mgr.; G. B. Staples, Jr. Sales Engr.; W. H. Steinkamp, Field Sales Mgr.; P. R. Vogel, Sales Engr.; C. D. Walker, Sales Engr.; W. P. Wills, Mgr. Research & Dev.; O. B. Wilson, Reg. S.M.; C. F. Woods, Reg. Valve S. M.

Mittelmann Electronics Corp.
Chicago 6, Ill. 610

Exhibiting: Electronic instruments.

In Attendance: Dr. Eugene Mittelmann, Wallace H. Coulter, R. A. Whiteman.

Moore Products Co.
Philadelphia 24, Pa. 109, 111

Exhibiting: New Products—Model M/P universal control station, can be used with controllers at process or in control room; Model 56 Nullmatic controller, remote-set type with built-in cut-off relay. **Regular Products**—Valve positioner; Nullmatic inverse derivative unit; Differential pressure transmitter; Thermometer; Pressure regulator; M/F relay; Indicating pressure transmitter.

In Attendance: C. H. Thompson, S.M.; H. S. Garrett, Mgr. Application Engrg. Dept.; R. A. Barnes Mgr. Houston; W. B. Miller, Sales Engr. Houston.

Moore & Co., Samuel
Mantua, Ohio 739

Exhibiting: New Products—Dekoron instrument tubing, 1/32" thick polyethylene or vinyl coating over steel, aluminum or copper instrument tubing, virtually corrosion-proof. **Regular Products**—Dekoron protected electrical conduit. Coating with plastic, tubular or bar shapes of any core material.

In Attendance: James F. Rogers, Ass't. S. M.; Carl P. Denson, Southwest Rep.

Moran Furnace & Sheet Metal Co.
Tulsa, Okla. 343, 345

Exhibiting: Meter houses; Instrument covers; Space and pipe line safety heaters.

In Attendance: W. O. Moran, Owner; H. A. Brown, Salesman.

Nash Engineering Co.
South Norwalk, Conn. 517, 519, 521

Exhibiting: New Products—"Clean-Air" brand instrument air compressors designed to furnish only clean air, free from dust, heat or oil, to pneumatic instrument lines. **Regular Products**—Pumps of many types.

In Attendance: Irving C. Jennings, Pres.; H. E. Adams, V. P. & Ch. Engr.; F. W. Green, Ass't. Sales Mgr. Ind. Equip.; E. A. Barton, Sales Engr.; G. B. Wright, Publ. Mgr.; R. Donnelly; R. B. Johnson, Houston; J. R. Dowdell, Dallas; R. S. Ryden, San Antonio.

National Bureau of Standards
Washington 25, D. C. 603, 605

Exhibiting: Aircraft stick-force indicator; Radiofrequency mass spectrometer; Spring transducer; Electronic micrometer; Pneumatic humidity indicator; Barium titanate accelerometer; I-F amplifier strips.

In Attendance: Samuel H. J. Womack; Charles Yost (Office of Air Research); Lt. Frank Thomas, USN (Office of Naval Research); W. A. Wildhack, R. O. Smith and Charles L. Bragaw (NBS).

New Hermes Engraving Mach. Corp.
New York 3, N. Y. 118

Exhibiting: Engravograph; Engraving machines, portable and bench type. Production engraving on metals and plastics.

In Attendance: N. Schimmel, R. Jacobs, G. G. Gruettner, M. Kaufman.

North American Philips Co.
Mount Vernon, N. Y. 704

Exhibiting: New Products—X-ray diffraction apparatus, 60-kvp-5ᵉ-ma, including generator and control system, tube housing, shutters, filters and rectifiers; Wide-range spectrometer goniometer for forward and back reflection regions; Electronic circuit panel with Geiger counter high-voltage supply, scale ratemeter and clock panel mounted in metal cabinet. **Regular Products**—Diffraction apparatus; Wide-range spectrometer goniometer; Electronic circuit panel; Philips EM-100 electron microscope; Powder cameras; Micro x-ray camera; Precision back-reflection focusing camera; Flat plate camera; Film illuminator and measuring device; Monochromator.

In Attendance: J. S. Buhler, Technical Commercial Mgr.

Palmer Thermometers, Inc.
Norwood 12, Ohio 140, 142

Exhibiting: New Products—Model 50-B wall-mounted and 50-C flush-mounted type, mercury-actuated dial-indicating thermometer with flexible connecting armor. **Regular Products**—Red-reading mercury industrial and laboratory indicating thermometers; 6 in. and 8 in. mercury-actuated dial and recording thermometer. Repair all makes industrial style thermometers, furnishing red-reading-mercury.

In Attendance: Bartlett Palmer, Pres.; Douglas H. Hitt, Dist. S. M.; Frank W. Probst, Sales Engr.

Panellit, Inc.
Chicago, Ill. 401, 403, 405, 407

Exhibiting: New Products—Monitoring systems; Panascan, scanning and switching systems; Mercury switch push buttonss. **Regular Products**—Graphic panels; Process panels; Panalarm systems; Annunciators; Level indicators. Control room design for power plants, chemical plants, refineries.

In Attendance: A. F. Sperry, Pres.; M. B. Lorig, Ch. Engr.; G. Mitchell, Engr. Panellit; R. A. Anderson, Ch. Engr. Panascan Div.; M. Tigerman, Mgr. Panalarm Prod. Div.

Penberthy Injector Co.
Div. Buffalo Eclipse Corp.
Detroit 2, Mich. 623

Exhibiting: New Products—High-pressure liquid level gages for pressures up to 20000 psi.; Floating shank liquid level gage valves which permit installation of assembled liquid level gages even though center measurements are off as much as 3/8 in. **Regular Products**—Bronze and iron liquid-level and water gage sets; Drop-forged steel reflex and transparent liquid-level gages and valves; Ejectors and exhausters; Explosion-proof sump pumps; Cycling jet pumps.

In Attendance: Fred E. Ruebelmann, V. P.; Chas. Denis, Ch. Engr.; Arnold Lindeman, Engr.; Howard Strohmaier, S. M.; Clarence A. Jennings, Ernie Piche, Howard Hurst, L. H. Weller, Malcolm Reed, Sales Engrs.

Perkin-Elmer Corp.
Norwalk, Conn. 306

Exhibiting: New Products—Mobile Model 12-C infrared spectrometer, "an analytical laboratory on wheels" with new accessories. **Regular Products**—Flame photometers; All-purpose monochromators; Infrared spectrometers; Electrophoresis apparatus. Optical and electro-optical design. Custom-built optical components.

In Attendance: Dr. Van Zandt Williams, Dir. Sales & Research; Paul A. Wilks, Asst. Dir. Sales & Research.

Potter Aeronautical Co.
Newark, N. J. 235

Exhibiting: Flow measuring equipment.

In Attendance: Robert Schooley; Richard Franks.

Proportioneers Inc.
Providence, R. I. 505, 507

Exhibiting: New Products—Fuel blender for automatically and continuously blending two liquids in a fixed ratio; Demonstration unit for mechanical differential Synchro-Master device; Automatic gasoline and lubricating oil blender with additional gravimetric equipment for dyeing and inhibiting gasoline. **Regular Products**—Adjust-O-Feeder; Treet-O-Unit.

In Attendance: R. P. Lowe, Pres.; P. V. Crowther, Ind. Engr.; J. R. Hefler, Dev. Engr.

Radio Corp. of America
Harrison, N. J. 705, 707

Exhibiting: Industrial electron tubes; Phototubes; Test equipment.

In Attendance: Howard Hafker, Robert Lord.

Refinery Supply Co.
Tulsa 3, Okla. 435, 437

Exhibiting: Ac-Me recording gravitometer; Ac-Me specific gravity balance; R. S. dead-weight tester; R. S. dead-weight gage; R. S. midget industrial thermometers; A.S.T.M. Yel-O-Bak flat-bore thermometers.

In Attendance: A. W. Chandler, Ch. Engr.; J. B. Okeson, S. M.; V. F. Sweeney, Jr., H. H. Holmes, D. D. Hampton, Sales Engrs.

Republic Flow Meters Co.
Chicago 47, Ill. 430, 432, 436

Exhibiting: New Products—Telemaster electronic master control system for steam generators and process control, eliminates effect of distance between central control board and points of regulation, will be in operation; Model P-0331 general-purpose differential-pressure transmitter, uses small lighter-weight measuring element than previous models; Batch control integrator, uses photoelectic pickup of watthour type integrator disk staff to operate predetermined electric counter to shut down flow after predetermined quantity has passed. **Regular Products**—Models P-0307 and P-0331 differential-pressure transmitters, pneumatic type; Pneumatic-electric integrating meter.

In Attendance: S. S. Williams, G. F. Norwood, W. E. Mannon, T. E. Bell, C. W. Parsons, Sales Engrs.; G. E. Lindemann, Design Engr.; G. S. Hendrickson, V. P.; J. B. McMahon, Mgr. Sales Pro.

Research Control Instrument Co.
Tulsa, Okla. 726

Exhibiting: New Products—Automatic controllers, 2-15-psi. output for pressure, level and flow, integral, panel or remote; Reversible top-work and bellows seals for research Minim flow valves; Regulator, back-pressure, self-operated, bellows diaphragm, all-stainless in 1/8 in. and 1/4 in. IPS; Displacement level controller, reversible, proportional, with or without air relay, miniature float operated from within gage glass. Relay valves, miniature, 3-way, 1/8 in., 1/4 in. and 1/2 in. IPS only; Steam-trace and ambient-temperature controller for steam, gas or fuel oil; Temperature controller, full-throttling, reversible, proportional and range adjustable, non-indicating (−50 F. to 1800 F.) with no thermocouple, filled bulb or resistance element. **Regular Products** Automatic control equipment in miniature; Minim flow valves up to 1/2 in. ISP only; Associated controllers, specialties, and specially designed components; Panel-board clocks, spring-wound and electric. Design, development and production of automatic control equipment.

In Attendance: Roy Horton, Owner; W. J. Claffie, Sales; W. A. Diament, Sales Consultant; Louise Horton, Sec.-Treas.; Paul G. Exline & Associates.

Robinson Orifice Fitting Co.
Los Angeles 23, Calif. 332

Exhibiting: New Products—Orifice fitting with pressure seal, suitable for 6000 psi. working pressure, hydrostatic test in excess of 10000 psi. **Regular Products**—Robinson Types "E" and "H" orifice fittings; Robinson flangeweld with meter runs; Orificemaster fitting.

In Attendance: M. N. Aitken, Robert Aiken, Robert Hazard, Allen Brown, Oliver W. Muff.

Rockwell Mfg. Co.
Pittsburgh 8, Pa. 706, 708, 710

Exhibiting: New Products—Standard 8-day chart drives; Midget chart drives, smaller than standard models; Rockwell instrument process control system, automatic sensitive control adapted to high-pressure balanced-valve regulators; Differential controller for orifice meter runs, used in connection with cylinder-operated Nordstrom plug valves. **Regular Products—**Mechanical chart drives; Orifice flow meters; Chart integrator; Gas test flow meter; Flow indicating meter; Displacement meter for liquid flow. Equipment for liquid and gas measurement for various types of industry.

In Attendance: J. L. Cottrell, Mgr. Integrator & Orifice Meters, Tulsa; C. K. Madison, Dist. Mgr., Houston; E. V. Bishoff, Sales Supervisor, Pittsburgh; E. A. Mowrey, Factory Service Engr., Pgh.; T. I. Stacy, Sales Engr., Houston; K. H. Rembert, Sales Engr., J. H. Walters, Super., R. J. Munn, Sales Engr., P. H. Luckett, Factory Service Engr., B. W. McKalip, Sales Engr.

Milton Roy Co.
Philadelphia 18, Pa. 426, 428

Exhibiting: New Products—"miniPump" and "miniAir" for controlled-volume pumping of clear liquids at pressures up to 20 psi, motor-driven by 1/12 or 1/6 hp. motors, types are simplex, duplex, multiplex (all delivers pulsating flow), and "Constametric" (delivers straight-line continuous flow). **Regular Products**—Simplex pump; Constametric pump; "AiRoy" pump; "miRO)metric" pressure generator, all controlled volume.

In Attendance: Robert T. Sheen, Pres.; Wm. T. Griffiths, V. P. Sales; Donald H. Jones, S. M.; M. N. Dannenbaum, Pres. M. M. Dannenbaum Co.; Stanley S. Williams, George Norwood, Neal R. Mannon, J. H. Palmer.

R-S Products Corp.
Philadelphia 44, Pa., 131, 135, 137, 139

Exhibiting: Butterfly valves; Leveltronic control system; Strainers; Shock absorbers.

In Attendance: R. C. Ayers, S.M.; G. B. Crawford, Ch. Engr.; H. Hollingsworth, Ch. Draftman; D. C. Culver, W. O. Ressler, J. P. Dugan, Sales Engrs.; O. W. Muller, P. F. La Roche, M. O. Schultz.

Ruska Instrument Corp.
Houston, Texas 615

Exhibiting: New Products Magnetic observatory instruments including earth-inductor and theodolite magnetometer; Bottom hole sampler for taking oil and gas samples from bottom of oil wel. **Regular Products** Magnetic prospecting, expedition and observatory instruments; Petroleum engineering and core analysis equipment.

In Attendance: W. B. Luton, J. W. Turner, Design Engrs.; R. W. Brennen, L. E. Jarrett, Physicists; S. H. Buckley, Prod. Engr.; C. Miks, Supt. Inst. Shop; W. R. Sudlow, Ass't. Prod. Engr.

Sarco Co., Inc.
New York 1, N. Y. 717, 719

Exhibiting: New Products Sarcostat Type "O" hydraulic motor-operated valve available in sizes 1/2 in. to 6 in. single-seated and 1/2 in. to 8 in. double-seated, for operation by remote manual switch or various types of thermostats or pressurestats; TR-19 temperature regulator, self-operated liquid expansion type regulator in 1/2 in. and 3/4 in., suitable for steam heating applications on pressures to 50 psi; Steam traps, Sarco float traps with thermodynamic air vent to prevent air binding of the trap under starting and operating conditions. **Regular Products** Self-operated and electric temperature controllers; Liquid blending valves; Level controls; Steam traps; Strainers; Air vents; Sight glasses.

In Attendance: A. Milnes, Dir.; H. F. Collins, Dir.; F. M. Esch, J. C. Waliler, D. G. Founds, Esch Condit Inc. Houston Reps.

Schutte and Koerting Co.
Cornwells Heights, Pa. 639, 641

Exhibiting: New Products Pneumatic, recording and controlling Rotameters available with receivers manufactured by most instrument companies. **Regular Products** Indicating Rotameters; High-pressure Rotameters; Recording Rotameters; Flow indicators; Specific gravity indicators; Electric recording Rotameters; Electronic recording Rotameters; Pneumatic recording Rotameters.

In Attendance: O. X. Heinrich, W. F. Dydak, H. O. Sears, Edwin T. Scruggs, B. C. Werlla.

Scientific Apparatus Makers Association
Chicago, Ill. 601

Exhibiting: Display of the services of the Scientific Apparatus Makers Assn. Literature will be made available.

In Attendance: Donald F. McCammon, Director of Public Information; Barbara Condo, Secretary, Public Information.

Servo Corp. of America
New Hyde Park, L. I., N. Y. 744

Exhibiting: New Products—Pyrometer; Type 2400 RF signal generator. **Regular Products**—Bolometer; Preamplifier; Power Supply; Servoscope; Servoboard; Servo amplifiers.

In Attendance: Henry Blackstone, S. N. Howell; Wm. Derganc; F. G. Willey; E. M. Wormser; T. A. Westover.

S. Morgan Smith Co.
York, Pa. 131, 135, 137, 139

Exhibiting: New Products—Non-lubricated plug valve for pipeline service; Package accumulator systems. **Regular Products**—Rotovalves, non-lubricated cone type valves; Angle needle relief valves; Howell-Bunger valves; Leonard trash rack rakes; Hydraulic turbines; Axial flow pumps for large capacities; Controllable-pitch ship propellers.

In Attendance: Carl J. Wilcox, Mgr. Valve Div.; George J. Wilkes, Dist. Mgr. Southwest Territory; Eugene H. Myers, Curtis W. Lau, Sales Engrs.

Southwestern Industrial Electronics
Houston 19, Texas 621

Exhibiting: New Products—Model "R" A-c. d-c. electronic voltmeter; Model "L" VLF oscillator; Model "D" d-c. amplifier; Model "C" resistance meter; Model "G" transducifier; "R" Series miniature transformer. **Regular Products**—Model M-2 wide-range oscillator; P-11 portable seismograph; CRO-1 multi-channel CR recording oscillograph; Model P-2 electronic potentiometer. Research and development.

In Attendance: H. J. Girard, V.P. Sales; Louis W. Erath, Ch. Engr.; Sidney Hatchel, Bob Meachum, Bill Kennedy, Engrs.

Streeter Amet Co.
Chicago 13, Ill. 110, 116

Exhibiting: New Products—Electronic scale, records weights and temperatures. **Regular Products**—Pulse-count recording instruments; Time-interval recording instruments; Revolution-count recording instruments; Predetermined counting instruments.

In Attendance: James Quinn, Paul Becher, John Marquardt, V. C. Kennedy, Jr., Engineers.

Superior Electric Co.
Bristol, Conn. 120, 122

Exhibiting: New Products—Varicell D-c. power supplies, provides a stabilized and regulated variable d-c. output voltage from fluctuating a-c. power lines. **Regular Products**—Powerstat variable transformers; Stabiline automatic voltage regulators; Varicell d-c. power supplies; Voltbox a-c. power supplies; Superior 5-way binding posts.

In Attendance: J. S. Louden, S. M.; L. R. Ward, John F. Gaumer, Dan L. Colbath, Sales Reps.; Walter A. Anderson, Ad. Dept.

Surprenant Manufacturing Co.
Clinton, Mass. 242

Exhibiting: New Products—Surflon (Teflon) insulated wire, high and low temperature operation (250 C. to minus 65 C.) low dielectric constant, high insulation resistance, low loss available in wire and small coaxial cables; Surflene (Kel-F) insulated wire, 150 C. resistance to flow at high temperatures, low dielectric constant, high insulation resistance, high dielectric strength, constant capacity, available in wire and coaxial cables; Surco-A-10 insulated wire, 105 C. vinyl, JAN-C-76 and Underwriters approved. Aircraft wires, low tension, good flexibility at high and low temperatures, resistant to moisture, acids, oils, synthetic hydraulic fluids light weight, emergency short circuit protection. **Regular Products**—Surco B-2 hook-up wire (JAN-C-76) coaxial cables and JAN-C-17a approved RG cables, shielded wires, multiconductor cables, tubing, hearing aid, extra flexible wire. Special cable and wire design.

In Attendance: Albert H. Surprenant, Pres. & S.M.; George E. Forsbeg, V.P. & Plant Mgr.; D. C. Alexander, Consulting Engr.; H. M. Robinson, Sales Engr.; R. Surprenant, Salesman.

The Swartwout Co.
Cleveland 12, Ohio 342, 344, 346

Exhibiting: New Products—Pressure, temperature, level and flow controllers; Manual-auto selector panels; Flow-regulating valves; Valve Positioners. **Regular Products**—Flow regulating valves; Pressure and temperature controllers.

In Attendance: Kenyon Swartwout, Ch. Engr.; Charles Swartwout, Development Engr.; R. K. Dick, Adv. Mgr.; M. M. Ward, Sales Mgr.

Taylor Instrument Companies
Rochester 1, N. Y. 511, 513, 515

Exhibiting: New Products—Transet Tri-Act controller, pneumatic force-balance non-indicating controller for pneumatic transmission systems features new control circuit with Pre-Act (rate response) acting before reset; Transet Bi-Act controller, pneumatic force-balance, proportional with reset only, one knob adjustment; Transaire differential pressure transmitter, force balance, companion instrument to Transaire temperature and pressure transmitters. **Regular Products**—Instruments for indicating, recording and controlling temperature, pressure, flow, liquid level, humidity and density.

In Attendance: R. E. Olson; F. S. Ward; A. J. Fleig; J. S. Detwiler; G. E. Heller; R. N. Pond; R. E. Clarridge; G. E. Howard; H. W. Stoll.

Telechron Inc.
Ashland, Mass. 236

Exhibiting: New Products—Type H-13 motor similar to Type H 3 but with newly-designed field structure. **Regular Products**—Synchronous timing motors; Electric chart movements; Commercial clocks; Timers.

In Attendance: D. E. Perry, Ind. Sales Mgr.; C. B. Dix, Motor Sales Mgr.; R. E. Zucker, Supervisor Motor Sales; M. C. Huie, Sales Rep.; F. T. Bees, Sales Engr.

H. O. Trerice Co.
Detroit 16, Mich. 310

Exhibiting: Thermometers—industrial, dial, recording; Controllers—self-operating, air-operated; Pressure gages; Air filters; Steam traps.

In Attendance: J. W. Darby, Houston Rep.; Donald Parker, Dist. Mgr.; S. B. Mercer, Divisional Mgr.; J. L. Brackett, Sales Mgr.

Trinity Equipment Corp.
Roselle Park, N. J. 410, 416

Exhibiting: New Products—Trin-Vue sight flow indicators, fabricated design using lap joint flanges and sealing the glasses in place with "O" rings, particularly intended for corrosive services. **Regular Products**—Thermocouple wells; Thermometer sockets; Thermometer test wells.

In Attendance: George R. Feeley, Pres.; James V. Mannion, V.P. Engrg.; Robert C. Axt, Sales Engr.

United States Gauge Div. of American Machine and Metals Inc.
Sellersville, Pa. 718, 720

Exhibiting: Diesel locomotive internally-illuminated pressure gage; 16 in. laboratory test gage; High-pressure solid-front protected gage; Remote-indicating hermetically-sealed aircraft transmitter; Protected and cleanout type chemical gage; Electric transformer pressure gages; Low-range absolute pressure gages; General-purpose welding boiler and household heating gages and thermometers; Pressure alarm switches.

In Attendance: I. N. Becker, V.P. & Gen. Mgr.; A. E. Le Van, Dir. Sales & Eng'rg.; Charles A. Frank, Jr., Gen. S.M.; Claude H. Fluck, Ass't. S.M.; J. H. Allen, Agent; E. G. Lagarde, Agent.

U. S. Navy Dept.
Washington, D. C. .....Lobby

Exhibiting: Electronic equipment; Ordnance equipment; Naval Research Laboratory equipment; Ordnance Laboratory equipment; Applied Physics Laboratory equipment.

University of Houston
Houston 4, Texas 737

Vapor Recovery Systems Co.
Compton, Calif. 431

Exhibiting: New Products—Fig. No. 253 Varec automatic tank gage, mechanical, installed on tank to indicate liquid level at tank by calibrated tape, tape drives electronic transmitter gager; Varec Fig. 850R electronic transmitter gager with Varec Fig. No. 801 electronic gager receiver, for remote reading of liquid levels when used with automatic tank gage; Varec field telephone link transmitter, allows accurate liquid level readings at desired remote points using telephone or power plant transmission.

In Attendance: Frank V. Long, Sr., Pres.; Frank W. Kendrick, Ch. Engr. Electronics Dept.; W. L. Killian, Mgr. Sales Pro.; John L. Shaunty, Houston Rep.

Veeder-Root, Inc.
Hartford 2, Conn. 402, 404

Exhibiting: New Products—Engine rev-hour meter; Ammunition rounds counter; New style predetermining counters; Panel-mounted magnetic counters; 360-degree indicator; New high-speed counter; Gas meter counter. **Regular Products**—Ratchet, revolution, direct-drive mechanical counters; Textile measuring counters; Predetermining magnetic counters, reset and non-reset.

In Attendance: W. R. Soderquist, Sales Engr.; N. B. Perkins, Dist. Engr.; C. C. Lombardi, Chicago Dist. Mgr.; G. L. Logan, Sales Mgr.

Wallace & Tiernan Products, Inc.
Belleville 9, N. J. 315

Exhibiting: Pressure gages; Vacuum gages; Mercury manometers; Dial manometers, Electric marine beacons.

In Attendance: Warren F. Haring, Sales Mgr.; Lester E. Demler, Sales Engr.; Carl C. Friedrichs, Dist. Mgr.

Weatherhead Co.
Cleveland 8, Ohio 202, 204

Exhibiting: New Products—Reusable hose ends and hose, low-, medium- and high-pressure hose for all industrial applications; Single- and double-fabric braid, double-wire braid and two types of single-wire braid with reusable ends for each; Bundyweld tubing, double-wall copper-brazed steel tubing for all industrial applications. **Regular Products**—Ermeto steel and stainless steel tube fittings; Pipe fittings; Steel SAE 37-degree flare fittings; Brass 45° SAE fittings; Brass compression and brass inverted flare fittings.

In Attendance: A. D. Hodge, S.M. Ind. Div.; A. J. Culbert, Ass't. S.M. Ind. Div.; N. C. DeVilling, R. E. Wolfe, J. R. Holiger, Sales Reps.; F. L. Nemeth, Service Engr.

W. M. Welch Mfg. Co.
Chicago 10, Ill. 209

Exhibiting: New Products—An accessory to convert the Densichron densitometer into a photometer for the color quality control of flour, stearic acid-ceramics and food products requiring diffuse illumination to correctly evaluate color. **Regular Products**—Duo-Seal high-vacuum pumps; Welch stainless steel trip balances; Electrical measuring instruments; Resistance boxes; Slide-wire rheostats; Densichron densitometer.

In Attendance: R. C. Hoffman, Sales Dept.; Charles Williams, Sales Engr.

Weston Electrical Instrument Corp.
Newark 5, N. J. 442, 444

Exhibiting: New Products—Averaging thermometer for volumetric determination of liquids in storage tanks; Weston recording potentiometer; Moisturonic moisture meter; Constant-current power supply instrument. **Regular Products**—Relays; Thermometers; Hydrometers; Test equipment; Photoelectric cells; Recorder-controllers; Portable testing instruments; Inductronic d-c. amplifier; Multiple indicating controllers.

In Attendance: R. T. Pierce, S.M. Theromotry and Control Div.; A. G. Koenig, Gen. S.M. Tagliabue Inst. Div.; L. Van Blerkom, S.M. Tagliabue Inst. Div.

Wheelco Instruments Co.
Chicago 7, Ill. 326, 328

Exhibiting: New Products—Multipoint strip-chart recorders, provide up to six permanent records of process variables on one chart, operate with primary elements such as thermocouples and radiation detectors; Capaciline, supplementary control device which anticipates the fuel needs of controlled heating equipments. **Regular Products**—Single-point strip-chart recorders; Pneumatic control strip-chart recorders; Flame-otrol combustion safeguard; Model 292 Capacitrol; Panelmount Capacitrol; Model 792 Limitrol; Six-point resistance thermometer controller; Portable pyrometer; Portable potentiometer.

In Attendance: Fred A. Hanson, Pres.; Chas. L. Saunders, Exec. V.P.; C. A. Gates V.P. East Div. Mgr.; R. A. Schoenfeld, V.P. West Div. Mgr.; E. Schneider, V.P. Res. & Devp.; R. Ramthun, Appl. Engr.; H. W. Bluethe, Adv. Mgr.; J. C. Freyberg, Ass't. Adv. Mgr.; Geo. Hatfield, Houston Dist. Sales.

R. L. Wilson Co. Inc.
Houston 3, Texas 741

Exhibiting: Tachometers (mechanical and electrical); Anenometers; Counters; Pressure and vacuum gages; Electrical instruments; Temperature controllers.

In Attendance: L. D. Stewart, Jr., V.P. and Mgr. Inst. Div.; J. C. Gilmore, S.M.; James M. McIver, V.P. and Mgr. Chem. Div.; C. W. Jones, Inst. Sales and Service; R. L. Wilson, Pres. and Gen. Mgr.

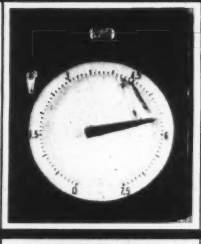
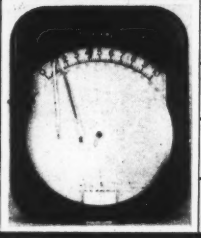
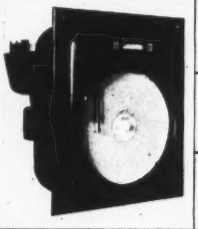
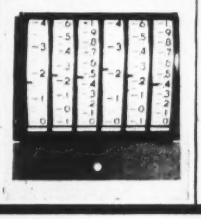
Wollensak Optical Co.
Rochester 21, Ill. 635

Exhibiting: New Products—Fastax high-speed motion-picture camera and accessories. A high-speed motion-picture laboratory will be in operation to illustrate the ease of analyzing motions that occur too fast for the eye to see in design, production, research and motion analysis. **Regular Products**—Lenses, showing a typical series for quality measurements.

In Attendance: John H. Waddell, Mgr. Fastax Div.; E. A. Springer, Pres.; Eugene Turula, Physicists.

get results with **HAYS**

in these 5 areas of measurement and control

		type	function	Indicating	Recording	Integrating	Controlling	write for bulletin
1 COMBUSTION CONTROL		Electric type for: Boilers {stationary / marine}	control of pressure, draft, airflow, fuel feed, and ratio				●	49-605
							●	42-520
		Glass & ceramics furnaces					●	47-842
		Metal heat-treating furnaces					●	48-750
		Open hearths					●	43-586
		Panels	Mounting of boilers & industrial instruments				●	50-773
2 GAS ANALYSIS		Chemical hand (orsat)	measurement of CO, CO^2 & O^2	●				47-668
		automatic	measurement of CO^2	●	●			49-550
		Electronic—automatic	measurement of O^2 and thermal conductivity	●	●		●	50-829
3 FLOW		Mechanical	measurement of steam, liquid, & gas flow	●	●	●		50-915
		Electrical	measurement of steam, liquid, & gas flow	●	●	●		50-800
		Positive Displacement	measurement of liquid flow	●		●		50-766
		Diaphragm	measurement of gas flow	●	●			42-562
4 LIQUID LEVEL		Mechanical	measurement of levels of all liquids —open & closed tanks	●	●			50-915
		Electrical	measurement of levels of all liquids —open & closed tanks	●	●			50-800
		Diaphragm	measurement of levels of all liquids —open tanks only	●	●			42-562
5 DRAFT		Diaphragm	measurement of low pressure, draft, & differential	●	●			50-667
							●	48-606

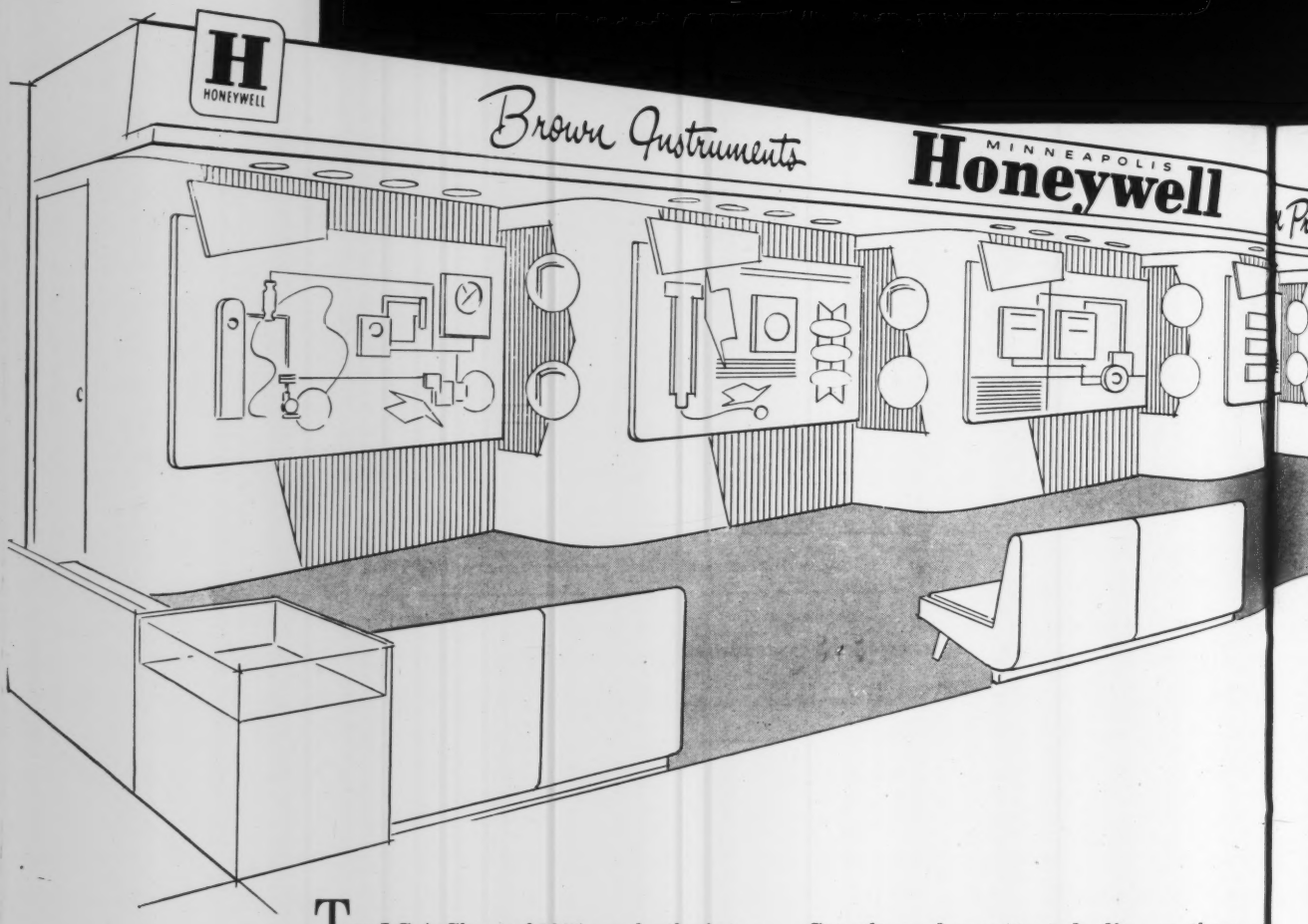
THE HAYS CORPORATION
MICHIGAN CITY 8 , INDIANA

Booth 245
at the Instrument Conference & Exhibit at Houston

INSTRUMENTATION

IN STEP WITH

PROCESS PROGRESS



THE I.S.A. Show of 1951 marks the introduction by Honeywell of an entirely new series of pace-setting developments in process control made possible through research and field engineering.

These outstanding contributions to process instrumentation bring greater precision and accuracy to civilian and defense production alike . . . from laboratory to pilot plant to full-scale operation.

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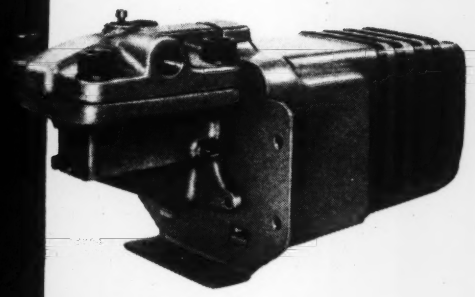
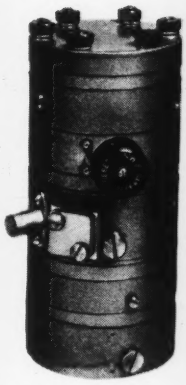
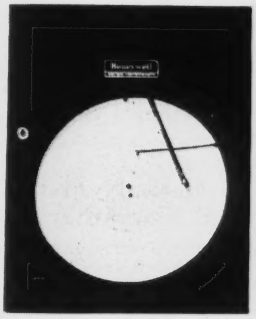
MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, 4482 Wayne Ave., Philadelphia 44, Pa.



Differential Converter
. . . the pneumatic-balance flow transmitter that features easy field calibration and wide rangeability.

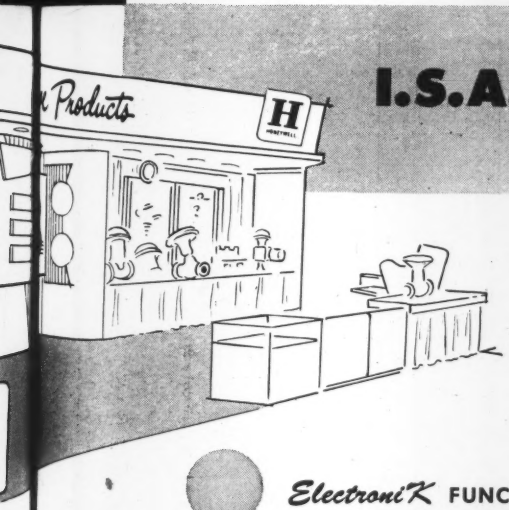


Tel-O-Set **CONTROLLER**
. . . the newest contribution to remote control that is keyed to the trend toward graphic panel instrumentation.



EVENLY DIVIDED FLOW METER
. . . featuring electronic integration and remote transmitter with characterized bell.

I.S.A. SHOW • booths 331 to 339



ElectroniK **FUNCTION PLOTTER**
. . . permits the recording of a continuous curve representing the relation of any two variables that can be reduced to a dc voltage.

ElectroniK **2-PEN RECORDER**
. . . records any two variables as a function of time; or, with modification, as a function of motion or displacement.

Electr-O-Line **RELAY**
. . . the electric position-proportioning relay, with automatic reset, that delivers a continuous heat input which is modulated according to exact process requirements.

Electr-O-Pulse **RELAY**
. . . the electric time-proportioning relay, with automatic reset, that delivers an intermittent full heat input which is modulated on a pulse/time basis.

Protect-O-Vane **CONTROLLER**
. . . electronic excess temperature safety cut-off controller protects equipment and work loads; features plug-in measuring and control units.

Micro **PRECISION SWITCHES**
. . . the space-saving switches with unusual capacity vs. size ratio, precisely designed and ruggedly constructed for long and repetitive operation.

NON-INDICATING CONTROLS
. . . non-indicating and non-recording control devices for simple and inexpensive regulation of most process variables.

PROCESS VALVES
. . . high and low lift proportional control valves, operators and components . . . hand Hi-Lift Valves . . . By-Passes . . . displacement type liquid level controllers.

MINNEAPOLIS
Honeywell
Brown Instruments

The Month's NEW INSTRUMENTS

In this department we report each month new devices for measurement, inspection, testing, computing, metering and automatic control—in the form of concise technical descriptions.

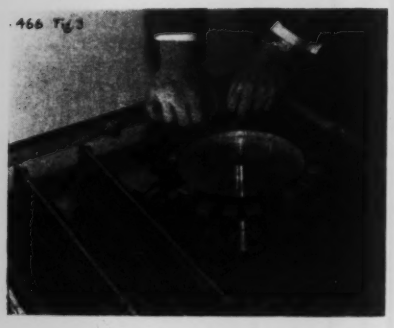
FOR FURTHER INFORMATION USE THE POSTAGE-FREE ORDER CARD ON PAGE 989

Differential-analyzer-type Digital Computer

New "Maddida" (pronounced "mad Ida"), small commercial model of Magnetic Drum Differential Analyzer built for Stevens Institute of Technology, measures 31 in. high by 21 in. wide by 54 in. deep and weighs 400 lbs., but

"its mathematical capacity places it in a class with warehouse-sized computers." In addition to being able to solve any simultaneous set of ordinary differential equations, it is said to be able to operate a chemical plant, for ex-

ample, by evaluating information from instruments, making decisions and commanding "valves, thermostats, stokers, tank levels, rates of flow, and so on." These plant-control functions are performed when proper connections are made to input and output terminal

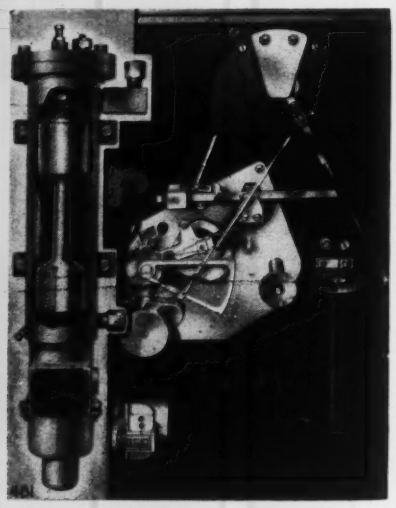


boards (I&O, Fig. 1). For use as a computer, "Maddida" can be operated by office personnel (Fig. 2). Among distinctive features are: revolving-drum metal "memory" which stores up to 10,000 digits and can find and use any stored number in less than a second, and use of hundreds of germanium crystals (Fig. 3) to minimize dependence on electron tubes.—*Northrop Aircraft, Inc., Northrop Field, Hawthorne, Calif.*

Mention No. 801 when filling out card.

Linear-scale Flowmeter

New model of maker's flowmeter, available in mechanical type with integral recorder or in electrical type with remote recorder, features redesigns of both meter body and instrument. New body (left-hand photograph) utilizes a bell-float acted upon by higher pressure on outside and lower pressure on inside, with mercury pool

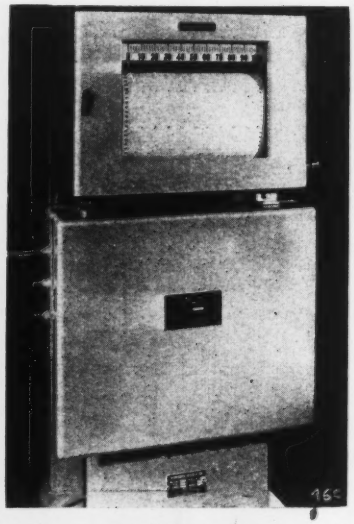


providing seal. Bell is so shaped that its vertical travel is proportional to square-root of differential. In mechanical flowmeter, bell motion is transmitted to recorder pen through a pressure-tight bearing and a lever-system; in electrical flowmeter, bell directly positions armature of inductance-bridge transmitter. New instrument's integrator utilizes an inductance-ratio tuned-circuit shielded-vane pickup to scan pen's position twelve times per minute and translate this periodic reading into a corresponding increment on a six-digit cyclometer register driven by a synchronous motor. Register has a seventh decimal wheel to facilitate calibration.—*Brown Instruments Div., Minneapolis-Honeywell Regulator Co., 4482 Wayne Ave., Philadelphia 44, Penna.*

Mention No. 802 when filling out card.

Recording and Controlling Infrared Gas Analyzer

New redesigned continuous analyzer is for plant stream service, incorporates new features said to make possible wider industrial application; permits easy accessibility for servicing by plant maintenance; is more adaptable to routine plant problems because of increased stability and accuracy over long periods and because of improved sensitivity and higher resistance to shock, temperature and humidity. Two explosion-proof



models are available: one a composite assembly of voltage regulator, detecting unit and recorder; the other a remote-control unit (detector as far as 600 feet from recorder). Redesigned unit provides a continuous quantitative analysis for a single infrared-absorbing component in a stream of gases. Ranges of concentration when calibrated for CO_2 to maximum sensitivity, 0 to 1 percent for 100 scale divisions; accuracy 1 scale division or 0.01 percent. Sensitivity depends on gas to be analyzed as well as other absorbing gases present in mixture. Instrument will command any final device which can be used with Minneapolis-Honeywell recorders.—*Baird Associates, Inc., 33 University Road, Cambridge 38, Mass.*

Mention No. 803 when filling out card.

Manual Polarographic Instrument

New "Model R1" is designed for research and routine polarography. Entire instrument is standardized against a standard cell: polarizing unit directly, galvanometer by means of polarizing unit and self-contained precision

where there's heat . . .

. . . there's a need for instant, accurate reading of surface temperatures to prevent costly damage to materials in process and equipment.

The handy Alnor Pyrocon is unequaled for quick, accurate reading of surface temperatures of molds, revolving rolls, bearings, steam traps, plastics, metals and many other materials. It's a well balanced, handy instrument that will stand heavy use, yet perform with laboratory precision.

A wide selection of thermocouples and extension arms assures its adaption to your type of service. Send for Bulletin No. 4257. Illinois Testing Laboratories, Inc., Room 518, 420 N. LaSalle Street, Chicago 10, Illinois.

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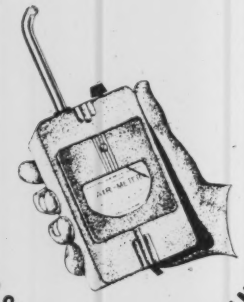
Address.....

City.....*Zone*.....*State*.....

For Measuring...

AIR VELOCITY

THE *HASTINGS* AIR-METER



SO SMALL IT FITS IN THE PALM OF YOUR HAND*

IDEAL FOR:

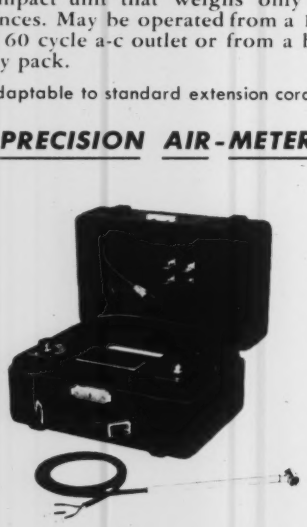
- Laboratories
- Schools
- Air Conditioning
- Heating
- Inspection Work
- Gas Flowmeter
- **Anywhere air or gas velocities are to be measured**

The HASTINGS AIR-METER is ideal for measurement of air and gas velocities from a low of 5 feet per minute up to 6,000 feet per minute. The instrument's unique principle of operation eliminates the effect of temperature and rate of temperature change. It is not affected by normal atmospheric pressure changes. A compact unit that weighs only 24 ounces. May be operated from a 110 V, 60 cycle a-c outlet or from a battery pack.

*Adaptable to standard extension cords

ALSO THE HASTINGS PRECISION AIR-METER

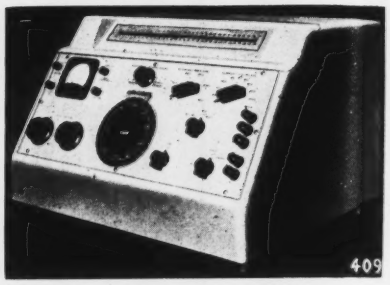
Developed for field or laboratory use where extreme sensitivity and stability are required. Operates on same principle as standard Air-Meter. Easily adapted for use as a flowmeter or with remote recording or indicating instruments. Reading indicator lag is less than one second. Other special probes available. WRITE TODAY for complete data on both Air-Meters.



HASTINGS INSTRUMENT COMPANY, INC.

HAMPTON, 5, VIRGINIA

DESIGNERS AND BUILDERS OF RAYDIST AND SPECIAL ELECTRONIC, ELECTRICAL, AND MECHANICAL INSTRUMENTS

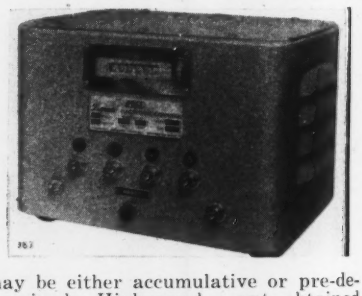


resistors. Metal case is 20 x 17 in. at base and 14 in. high. Features include a 25-turn helical voltage divider accurate to 0.1 precent, reading to one millivolt with a span voltage of 2.5 v. and to 2 mv. at a span voltage of 5.0 v.; low-resistance galvanometer with sensitivity approximating 0.005 microamperes per millimeter. Multiple shunt from 1× to 300×. Scale length: 320-mm. Mfr. is Patwin Instruments Div.; Waterbury 20, Conn. Distributor will be *General Scientific Equipment Co., Hamden, Conn.*

Mention No. 804 when filling out card.

Electronic Counter

New "Promatic" counter has facilities for total count, rate of count, and predetermined count. Can count in excess of 10,000 units per sec. Operation

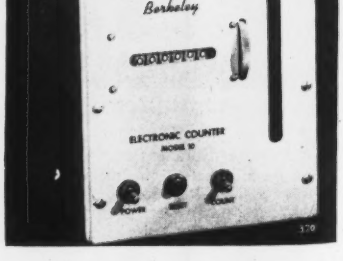


may be either accumulative or pre-determined. High-speed count obtained by photocell and electronic circuits; six-digit totalizer indicates exact count. Counter may be located 75 feet from photocell head.—*General Controls Co., Boston 34, Mass.*

Mention No. 805 when filling out card.

Electronic Counter

New "Model 10" counter counts at rates up to 6000 per minute and differentiates between any two occurrences as close together as 20 microsec-

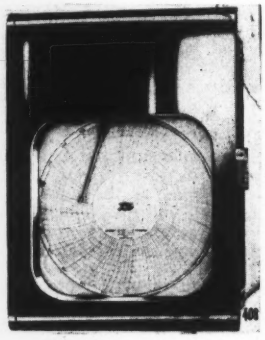


onds. Utilizes selenium rectifiers in power supply. Deviations in counting rate do not affect accuracy. Total capacity is 9,999,999 counts. All wiring is moisture- and fungus-proofed. Circuits developed around one tube, the 12AU7. Operates on 105 to 130 volts, 25 watts.—*Berkeley Scientific Corp., 2200 Wright Ave., Richmond, Calif.*

Mention No. 806 when filling out card.

Running-time Recorders

New line of maker's running-time recorders provide chart records which give total "on" time in hours, minutes, and seconds for a given period; also



"time off" periods with the time at which they occurred. Feature is that running-time readings are magnified so that total operating time of a machine can be determined to within a few seconds. New recorders are furnished in models suitable for wall, flush-panel or portable use.—*The Bristol Company, Waterbury 20, Conn.*

Mention No. 807 when filling out card.

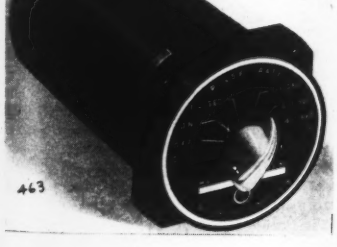
Interval Timer

New "Dual-Speed" electric interval timer for gas and electric ranges provides settings of 0.5 min. intervals for first 15 min. and 5-min. intervals after 15 minutes. Features a continuous buzzer signal. Operates 85 minutes.—*International Register Co., 2614 W. Washington Blvd., Chicago 12, Ill.*

Mention No. 808 when filling out card.

Intervalometer

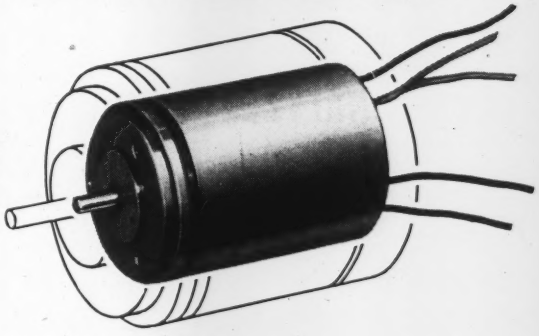
New "Model 21320" pulse-generator intervalometer has four settings: 1 per 2 sec.; 1 per 1 sec.; 2 per 1 sec.; 4 per 1 sec. Other rates available in these ratios, up to 10 per second. Pulse duration, regardless of dial setting, is 1/25 sec.; accuracy ±5 percent. Instrument



ECLIPSE-PIONEER

Announces the New Line of

PYGMY SYNCHROS



Size of pygmy as compared to AY-200 series outline

Eclipse-Pioneer has added a tiny new member to its great family of famous Autosyn* synchros. It's the new AY-500 series, a precision-built pygmy weighing only 1¾ oz. while scaling only 1.278″ long and .937″ in diameter (the same diameter, incidentally, as a twenty-five cent piece). Its accuracy and dependability are assured, thanks to Eclipse-Pioneer's 17 years of experience and leadership in the development of high precision synchros for aircraft, marine and industrial applications. For more detailed information on the AY-500 and other E-P Autosyns, such as the remarkably accurate AY-200 series (guaranteed accuracy to within 15 minutes on all production units), please write direct to Eclipse-Pioneer, Teterboro, N. J.

*REG. TRADE MARK BENDIX AVIATION CORPORATION

LOOK FOR THE PIONEER MARK OF QUALITY
REG. U.S. PAT. OFF.

Typical Performance Characteristics

	One AY-201-3 Driving		One AY-500-3 Driving
	One AY-500-3 Control Transformer	Two AY-500-3 Control Transformer	One AY-500-3 Control Transformer
INPUT			
Voltage	26-volts, single-phase	26-volts, single-phase	26-volts, single-phase
Frequency	400 cycles	400 cycles	400 cycles
Current	88 milliamperes	110 milliamperes	55 milliamperes
Power	0.8 watts	1.2 watts	0.9 watts
Impedance	105+j280 ohms	100+j220 ohms	290+j370 ohms
OUTPUT			
Voltage Max. (rotor output)	17.9 volts	16.2 volts	14.1 volts
Voltage at null	40 millivolts	40 millivolts	40 millivolts
Sensitivity	310 millivolts/degree	280 millivolts/degree	245 millivolts/degree
Voltage phase shift	23 degrees	26 degrees	44 degrees
System accuracy (max. possible spread)	0.6 degrees	0.6 degrees	0.75 degrees

Other E-P precision components for servo mechanism and computing equipment:

Servo motors and systems • rate generators • gyros • stabilization equipment • turbine power supplies • remote indicating-transmitting systems and special purpose electron tubes.

For detailed information, write to Dept. A

ECLIPSE-PIONEER DIVISION of Bendix AVIATION CORPORATION

TETERBORO, NEW JERSEY

Export Sales: Bendix International Division, 72 Fifth Avenue, New York 11, N. Y.

CONTINUOUS ANALYSIS

NO LABORATORY SAMPLING

INCREASED THROUGHPUT

Baird Associates

NEW MODEL

PLANT GAS ANALYZER

BA incorporating many requisites for plant stream service: simple components, ease of maintenance, explosion proof housing, rugged compact construction, low cost, etc. . . .

Presently used for the measurement and determination of:

ETHYLENE
in ethane and methane

METHANE
in other hydrocarbons
in illuminating gas

ETHYL ACETATE
in toluene, ethyl alcohol

ACETONE
in air

CARBON MONOXIDE
in air, CO_2 H_2O

CARBON DIOXIDE
in air, CO, water vapor

ISOBUTANE
in normal butane, other HCs

ACETYLENE

WATER VAPOR
in CO, CO_2, N_2

Please write for application questionnaire on these and many other problems.

The redesigned instrument will be demonstrated at Houston, ISA, Booth 215 September 10-14.

Baird Associates Inc.

33 University Road Cambridge 38, Mass

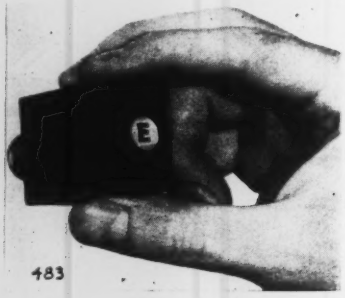
NEW INSTRUMENTS

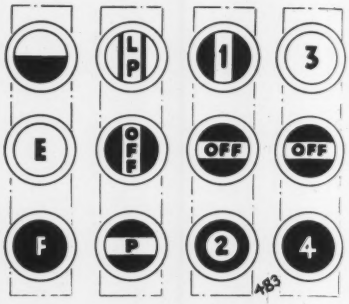
has compensation for temperatures from −50 F. to +150 F. and accelerations to 15 G; is filtered for radio interference; may be obtained hermetically sealed.—*Photographic Products, Inc., 6916 Romaine St., Hollywood 38, Calif.*

Mention No. 809 when filling out card.

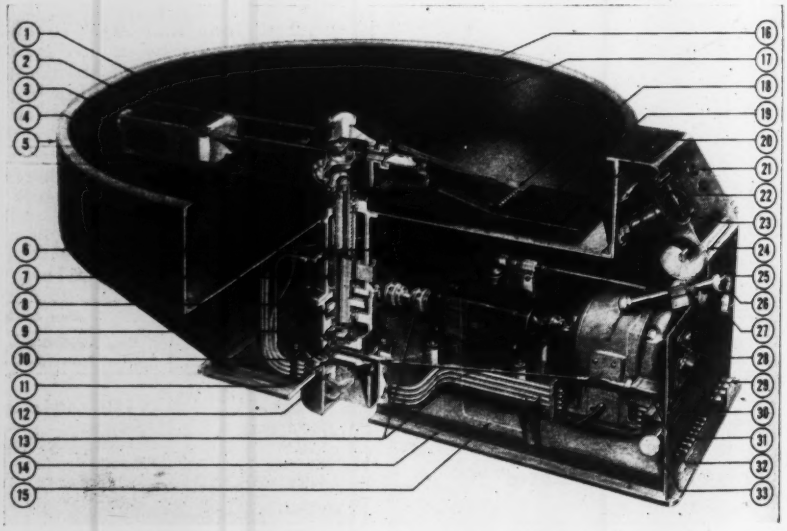
Three-position Indicator

New remote-reading three-position indicator (based on maker's aircraft landing-gear position indicator) consists fundamentally of a rotating card which exhibits one of three printed symbols. Two solenoids draw card up or down to extreme positions; when neither is energized, spring-balanced cylindrical card returns to neutral position, exhibiting third symbol. Solenoids can be actuated by float, pressure, or contact switches. Sealed brass case is impervious to dust and dirt; will pass salt-spray and immersion tests; can be filled with inert gas if required. Unit withstands temperature tests from −85 F. to +158 F.; will pass usual aircraft vibration tests. Symbols on card can be designed to meet requirements; can be applied in colors, or luminous paint.—*Special Products Div., The Riverside Metal Co., Riverside, N. J.*





Mention No. 810 when filling out card.



"G" Standard for Testing Accelerometers, etc.

New "G Accelerator" applies a steady force of variable magnitude to instruments and component parts for aircraft and guided missiles. Uses: (a) calibrating acceleration indicating or reacting devices; (b) functional testing. Device to be tested is mounted on Mounting Pad (19) and CG or responsive-point relationship with axis is located from Radius of Gyration Scale (20). Adjustable Counterweight (1) is adjusted. Speed required to apply desired force is selected from RPM Radius of Gyration "G" Unit (24). Electrical connections to device under test are made to Electrical Taps to Console (18) and to measuring or power supply elements at eight Collector Rings (8) to test object. Air connections may also be made at Air Outlets to Panel (29) and from Air Outlets to Table (2) to test object. Optical Path Directional Adjustment (17) is made and proper magnification ratio lens rotated into optical path, with aid of Sight Scope (25) and Focus Adjustment (26). Machine is started by switch (21); speed is increased by Table Speed Control (27) which controls Hydraulic Speed Unit (6), while observing Tachometer Indicator (23). When selected speed is reached, 0.1-120 sec. Timer (28) is set; Timer Push Button (22) is depressed, starting time interval and energizing Revolution Counter Clutch (32). Table Revolution Counter (30) will indicate total number of revolutions to nearest 1/10 part in time interval selected. Counter may be reset to zero by knob (33) and a second

Igloo or Jet Engine...

Wherever temperatures are important to you, there's a dependable American Thermometer or Temperature Measuring Instrument for the purpose. The line is so complete, selection for specific needs is easy, whether you require accurate temperature measuring instruments to safeguard product quality, protect equipment or control costs.

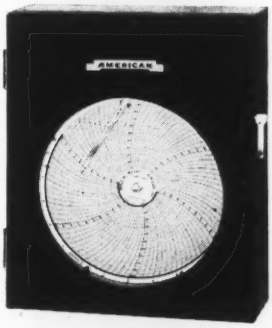
American Thermometers and Temperature Indicators and Recorders are available in ranges from minus 100°F. to plus 3000°F., with *actuation by mercury, vapor pressure, gas, bi-metal or thermocouple* —depending on instrument type and requirements. And, to indicate or record temperatures accurately as far as 250 feet from the temperature source, famous "Magic Pulse" self-compensating capillary tubing can be supplied.

Whether you must know the exact temperature of a kiln, processing vat, deep freeze – anything hot or cold – choose from the many fine American Thermometers and Temperature Measuring Instruments. New catalog gives complete details.

Stocked and Sold By Leading Distributors

AMERICAN RECORDING THERMOMETERS

Single, double, or triple pens in round or rectangular cases. 10-inch chart with effective scale width of 3⅝" for easy, accurate reading. Chart Drive: 24-hour spring wound or electric. Actuation: mercury, vapor pressure, or gas. Ranges from minus 60°F. to plus 1000°F.



AMERICAN TEMPERATURE INDICATORS

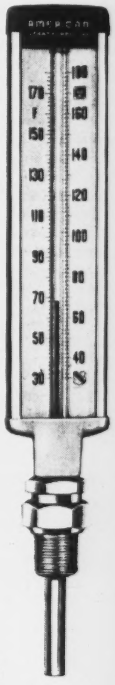
A radically new pyrometric-type instrument. Combines the unique Microsen Balance with the sensitivity of thermocouple measurement. Extremely accurate, rugged, dependable. Power actuated pointer. Ranges from minus 100°F. to plus 3000°F. American Temperature Recorder also available.

AMERICAN DIAL THERMOMETERS

Clear, bold figures on exactly graduated dials; pointer of contrasting color. Actuation: mercury, vapor pressure, gas, or bi-metal. Ranges from minus 60°F. to plus 1000°F. Cases for stem, wall, or flush mounting.

AMERICAN INDUSTRIAL GLASS THERMOMETERS

Full scale opening of 7", 9", or 12" with easy-to-read red mercury tubing. Ranges from minus 80°F. to plus 1150°F. Straight and angle forms.



1850 AMERICAN U S A

AMERICAN INDUSTRIAL INSTRUMENTS

MAXWELL MANNING M&M & MOORE INC. TRADE MARK

A product of **MANNING, MAXWELL & MOORE, INC.** STRATFORD, CONNECTICUT

MAKERS OF 'AMERICAN' ELECTRICAL AND INDUSTRIAL INSTRUMENTS, 'HANCOCK' VALVES, 'ASHCROFT' GAUGES, 'CONSOLIDATED' SAFETY AND RELIEF VALVES. BUILDERS OF "SHAW BOX" CRANES, 'BUDGIT' AND 'LOAD LIFTER' HOISTS AND OTHER LIFTING SPECIALTIES.

NEW ONE-PACKAGE CONTROL SYSTEM

for

DIFFERENTIAL TRANSFORMERS

or

STRAIN GAGES

at the Flip of a Switch

DYNA-MYKE

The Dyna-Myke Model 129-B is a precision, high speed, dynamic micrometer using linear differential transformers as the sensing element. It measures and provides for recording such phenomena as force, torque, strain, vibration, acceleration, temperature, pressure, thickness, surface finish, etc., with a linear frequency response of DC to 1000 cps. Direct displacements are measured in five ranges from ±.1 inch to ±10 micro inches. On standard magnetic recorders a sensitivity of 1 micro inch per millimeter is available. A toggle switch converts the Dyna-Myke to a high frequency, high sensitivity strain gage indicator. The output is used to drive any type of magnetic, null balance or galvanometer recorder—or the DC or modulated carrier may be viewed on an Oscilloscope. Selsyn motors may be driven for remote indication or control. Request Technical Bulletin 129-B for full details.

DYNA-METER

The Dyna-Meter Model 144, when used with the Dyna-Myke, indicates by neon lights the peak amplitude of transients as fast as 1 millisecond. This indication may be instantaneous or a memory feature may be used to maintain the reading until reset. Built-in power relays provide on-or-off control to any plus or minus limits established by the Dyna-Myke. The combination of the Dyna-Myke and the Dyna-Meter offers many applications to industrial processes resulting in the elimination of scrap *at the source*. Uses in connection with machine tool operations are particularly impressive. Request Dyna-Meter Technical Bulletin 144.

Custom Builders of Electronic Instruments Since 1943

INDUSTRIAL ELECTRONICS, INCORPORATED

8064 Wheeler St., Detroit 10, Mich.

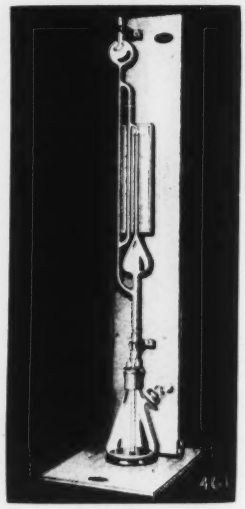
NEW INSTRUMENTS

count made immediately. Unit is ruggedly constructed of Dural. Heavy Guard Rail (5) prevents possible harm from objects inadvertently left unsecured on table. Vibration Isolating Pads (13) eliminate troublesome vibration to test object. Performance data: Speed range, 0-410 rpm; force range, 0-110 G; load capacity, to 25 lbs. @ 50 G, 15 lbs. @ 75 G and 10 lbs. @ 110 G; accuracy, 0.1 rev. at all speeds; drift, less than 0.5 percent; vibration, 0.03 G resolution.—*Genisco Inc., 2233 Federal Ave., Los Angeles 64, Calif.*

Mention No. 811 when filling out card.

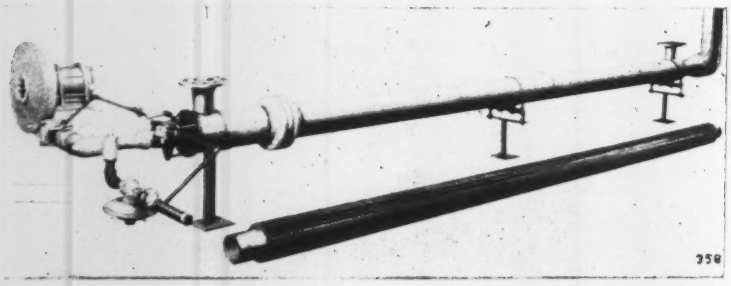
Vacuum Gage

New McLeod gage, suitable for ASTM. proposed test for reduced pressure distillation of petroleum products, has scales graduated in both "square" and "linear" systems. Readings are made directly in mm. values, and individual precise calibrations of ratios of volumes can also be made directly. Other features include a trap to prevent mercury overflow, extra-heavy-wall mercury reservoir, air filter to prevent contamination of system, plus a constriction of main tube that prevents breakage of flask by a sudden return of mercury. Range: 0.1 mm. to



20 mm. linear, and 0.01 mm. to 20 mm. square.—*Emil Greiner Co., 20-26 N. Moore St., New York 13, N. Y.*

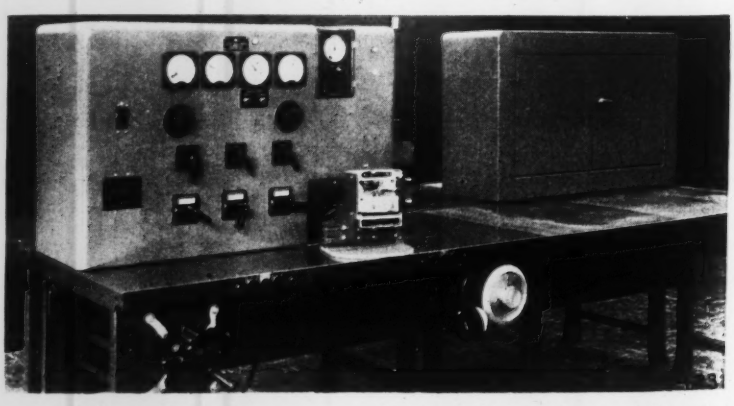
Mention No. 812 when filling out card.



Heater

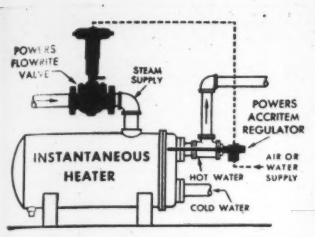
New "Type 102 Fintube" consists of stainless-steel outer shell with expansion section and Inconel center tube, with integrally-welded extended-surface nickel fins. Heats air, special atmospheres, gases, or liquids without contaminating them with products of combustion. Temperature ranges to 1600 F.—from atmospheric to high presures. Heaters use oil or gas fuel.—*Brown Fintube Co., Elyria, Ohio.*

Mention No. 813 when filling out card.



Relay Test Set

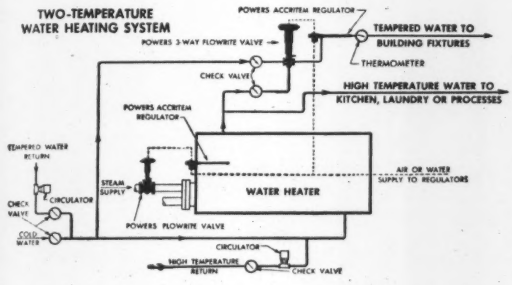
New "Model SP-MBE All-in-one" single-phase relay test board provides facilities to test single-phase power system relays and single-phase elements of polyphase relays. All instruments and controls are mounted on front vertical surfaces of board and of bench. Alternating current output ranges: 1, 5, 10, 25, and 125 amps; a-c. potential output ranges: 1.5, 7.5, 30, and 150 volts. Phase-angle meter measures electrical degrees between current and potential circuits. One 3-amp. 6-volt d-c. output circuit permits use of

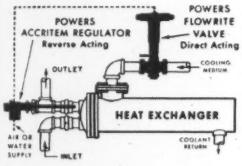


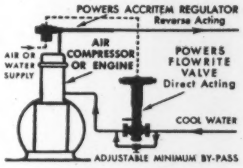
POWERS

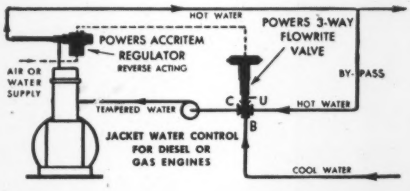
ACCRITEM REGULATOR

Only a few of many uses









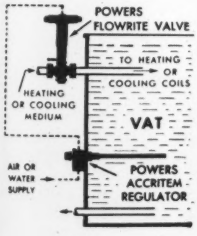
Gives

Accurate, Low Cost Heat Control

Use Accritem Regulators to control diaphragm operated valves or dampers. They save labor, stop losses caused by over-heating and have the following —

IMPORTANT ADVANTAGES

- ***Adjustable Sensitivity*** and over-heat protection.
- ***Calibrated Dial*** temperature adjustment.
- ***Simple, Rugged Construction*** withstands vibration and insures many years of reliable service.
- ***Temperature Ranges*** 50 to 250° F. and 150 to 350° F.
- ***Easy to Install*** Requires 15 lb. supply of compressed air or water for its operation.
- ***Small Size*** — regulator head is only 2⅞" x 3⅝", sensitive bulb is 12" long with ½" I.P.S. connection.



POWERS

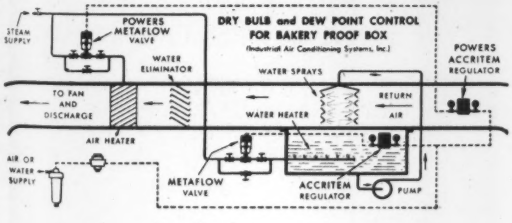
FLOWRITE **and** METAFLOW

Diaphragm Valves

controlled by a POWERS

ACCRITEM HEAT REGULATOR

provide an unbeatable combination for *better control and lower maintenance*



Write for Bulletin 316—or phone our nearest office for prices and further information about POWERS ACCRITEM regulators and diaphragm valves.

THE POWERS REGULATOR CO.

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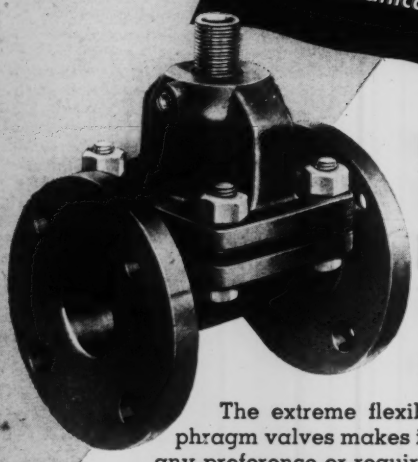
MEXICO, D. F., Apartado 63 Bis. (AMG)

60 Years of Temperature and Humidity Control

Any of these "Proven Operators"

- ✓ Westinghouse, Bendix Westinghouse
- ✓ Barber-Colman, Cutler-Hammer and Philadelphia Limitorque motors
- ✓ All pneumatic motors
- ✓ Air loaded pneumatic motors
- ✓ All double and single action air cylinders
- ✓ Mechanical springs



may be used with HILLS-McCANNA Diaphragm Valves for automatic or remote operation

The extreme flexibility of Hills-McCanna diaphragm valves makes it possible to satisfy virtually any preference or requirement in the use of mechanical operators. All of the operators listed above plus others are applied to standard Hills-McCanna sliding stem valves to provide complete units that utilize your existing operating methods.

Designed especially for conveying "hard-to-handle" fluids such as acids, alkalis, volatile and viscous substances, slurries, semi-solids, etc. Hills-McCanna diaphragm valves give you the advantages of "special" design on a standardized basis. Sizes range from ⅜" through 14" (not all methods of operation are available in all sizes); pressure up to 150 psi; temperatures to 180°F. (some applications to 220°F.). Write for complete information, HILLS-McCANNA CO., 2364 W. Nelson Ave., Chicago 18, Ill.

HILLS-McCANNA

Saunders patent diaphragm valves

Proportioning Pumps

Force-Feed Lubricators • Magnesium Alloy Castings

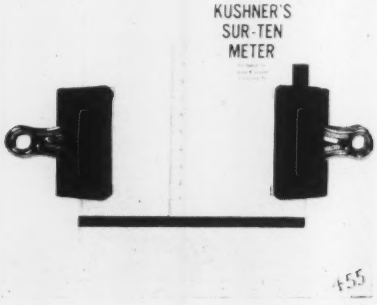
NEW INSTRUMENTS

conventional cycle-counter to indicate relay tripping time. Delivery 90 days. —*Arthur E. Booth Co.*, 4124 *Beverly Blvd., Los Angeles* 4, *Calif.*

Mention No. 814 when filling out card.

Surface Tension Instrument

New "Sur-Ten Meter" is for routine surface tension control under production conditions; can be used by inexperienced personnel. Surface tension

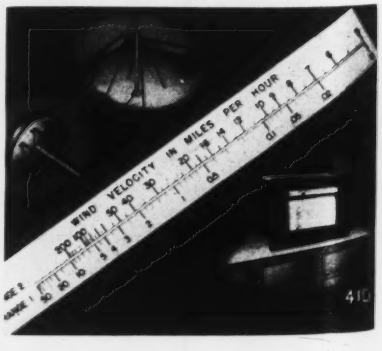


measurements can be made in less than five minutes where accuracy to within two to five percent is sufficient. It is made of plate glass, 7 x 5 x 1 in. Scale is printed with a fired ceramic enamel so that instrument can be used in contact with all solutions except those containing free fluorine ions.—*Joseph B. Kushner Laboratories, Stroudsburg* 1ST, *Penna.*

Mention No. 815 when filling out card.

Wind Velocity Recorder

New wind velocity recorder provides both instantaneous indication and a strip chart record of wind velocities between 0 and 200 mph.: range 1, 0-50 mph., range 2, 5-200 mph., on logarithmic scales. Range switching is either manual or automatic. Instrument is furnished with either a directional or a horizontally non-directional probe. Probes are of thermopile type: no moving parts, compensated for temperature and rate-of-change of temperature. Accuracy and calibration unaffected by lead length, nor by aging or exposure of probe. (Special: thermostated heater in probe to prevent icing.) Operation is from 110-volt 60-cycle supply. Voltage regulation eliminates effect of line voltage variations. Recorder may be supplied with either

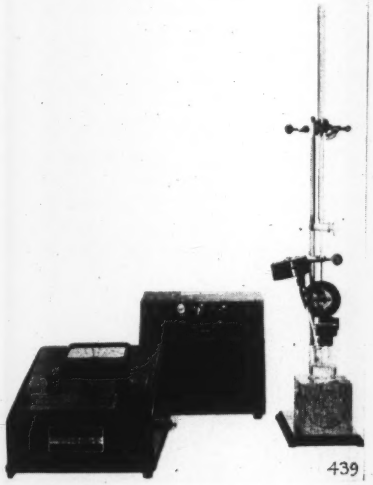


a quick response for high sensitivity or a damped response for average-velocity readings. A wide choice of chart speeds is available.—*Hastings Instrument Co., Inc., Super Highway and Pine Ave., Hampton 10, Va.*

Mention No. 816 when filling out card.

Automatic Titrator

New "Model 19 Autotrator" is said to provide high-speed fully-automatic titration at minimum cost. Titrant is delivered rapidly until end-point ap-

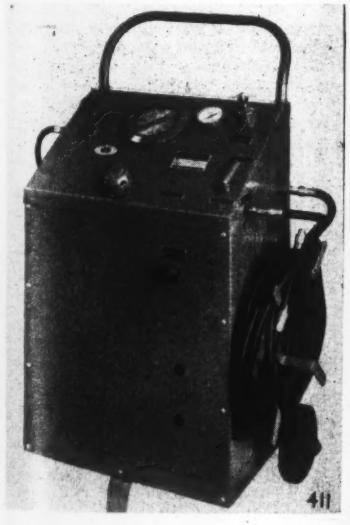


proaches, then final portions are added in progressively smaller increments until true end-point is reached. Operation is controlled by maker's "Model 18 ph Electrometer" which continuously indicates progress of titration.—*Coleman Instruments, Inc., 318 Madison St., Maywood, Illinois.*

Mention No. 817 when filling out card.

Tester for Hydraulic Components and Systems

New "Model S-404" portable hydraulic power unit is designed for simplified operational and proof testing of hydraulic components and sys-



ELECTRONIC INSTRUMENTATION

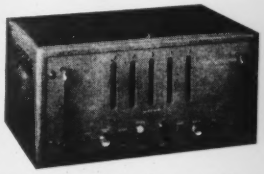
for LABORATORY *or* PRODUCTION LINE!

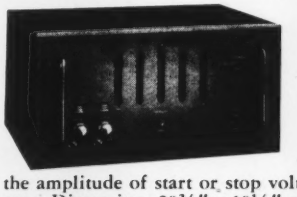
DECIMAL COUNTING UNIT, MODEL 700 is a direct reading electronic counter capable of operating at speeds up to 30,000 counts per second. Digits from 0 to 9 are presented on illuminated front panel. Electrical reset to zero. Plug-in octal mounting for easy interchangeability. The counter operates on input pulse of 100 volt neg. with 2 microsec. max. rise time. Output will drive following unit in cascade. Dimensions 1⅜" x 5" x 5¼". Wt. 12 oz. Other models to a million counts per second.

ELECTRONIC COUNTER, MODEL 10 was developed to meet the need for a rugged industrial counter operating at speeds up to 6000 counts per minute. Total count is displayed on the Decimal Counting Unit and the mechanical register to a maximum capacity of 9,999,999. Unit may be operated from closing contacts, photocell, or any means that will supply a positive potential of at least 3 volts. All circuitry moisture and fungus proofed. Unit is available in a variety of vapor-proof and explosion-proof housings to meet individual requirements. Dimensions 6¼" x 7¼" x 6½". Weight approximately 6 lbs.

PRESET COUNTER consists of a series of scale-of-10 electronic counting units each in parallel with a 10-position push-button switch. This instrument accepts counts in the conventional manner at rates up to 10,000 cps. Any number from 0 to maximum capacity may be preset merely by depressing appropriate push-button in each column. Upon reaching the preset count, the unit supplies an output pulse to drive a register, close a gate, divert a production line or perform any other desired function. It then resets to 0 and recycles automatically. Available in any desired capacity.

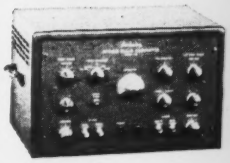
EVENTS PER UNIT TIME METER, MODEL 554 will automatically count and display the number of events that occur during a precise one second interval at rates up to 100,000 events per second. Accuracy is ± one event. Will operate either manually or automatically to count any mechanical, electrical, or optical occurrences, regularly or randomly spaced, that can be converted into changing voltages. Instrument counts for one second and displays the results on illuminated five-digit panel. Will recycle continuously on automatic operation. Convenient test switch permits 2 second self-check of entire unit. Dimensions 20¾" x 10½" x 15". Weight approximately 68 lbs.





TIME INTERVAL METER, MODEL 510 provides a direct reading of elapsed time between any two events in the range of 0.000010 to 1.00000 seconds. Accuracy is ± 10 microseconds. Any occurrences that can be translated into changing voltages may be so timed. Timing may be started and stopped by independent voltages, the polarity of which may be selected by means of toggle switches. Sensitivity control permits selection of the amplitude of start or stop voltages at optimum level for elimination of interference. Dimensions 20¾" x 10½" x 15". Weight approximately 58 lbs.

SINGLE/DOUBLE PULSE GENERATOR MODEL 903 is a general purpose laboratory instrument that supplies either single or paired pulses individually variable in amplitude, width and polarity. Pulse spacing is continuously variable from 0 to 10 microseconds, pulse width from 0.10 to 1.6 microseconds and pulse amplitude from 200 volts maximum negative and 50 volts maximum positive for 1000 ohm load, and 10 volts maximum negative and 50 volts maximum positive for 50 ohm load. Single or double pulses are available through separate panel connectors. Repetition rate internally controlled 1 to 1000 cps. Push-button control single cycle. External signal control for any rate up to 1000 cps.



These are basic descriptions of representative standard instruments. A variety of modifications, both standard and special, are available to meet specific requirements. For complete details write Dep't. .

Berkeley Scientific Corporation

2200 WRIGHT AVE. • RICHMOND, CALIF.

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YOUR SAFETY VALVES CAN BE BOOBY TRAPS

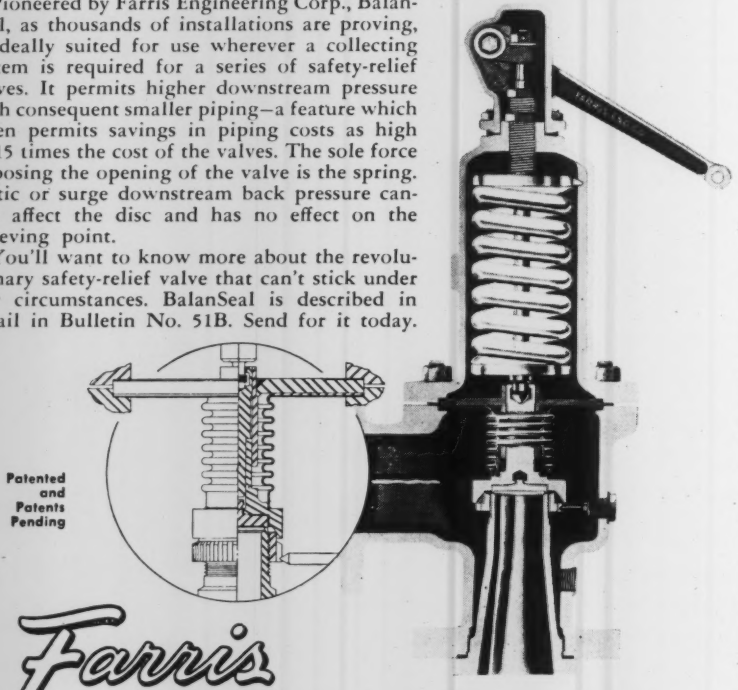
A safety valve that sticks is about as safe as a time bomb

Only BalanSeal© and FarriSeal© provide the positive protection at all times and under all operation conditions that makes them reliably safe.

Unique in design and principle, the BalanSeal Safety-Relief Valve has a protective bellows which is proportioned to eliminate any unbalanced downstream forces on the valve disc—which is perfectly balanced on its seat at the set pressure. Like its companion, the FarriSeal Valve, the guide, stem and spring are completely isolated from the lading fluid for perfect protection.

Pioneered by Farris Engineering Corp., BalanSeal, as thousands of installations are proving, is ideally suited for use wherever a collecting system is required for a series of safety-relief valves. It permits higher downstream pressure with consequent smaller piping—a feature which often permits savings in piping costs as high as 15 times the cost of the valves. The sole force opposing the opening of the valve is the spring. Static or surge downstream back pressure cannot affect the disc and has no effect on the relieving point.

You'll want to know more about the revolutionary safety-relief valve that can't stick under any circumstances. BalanSeal is described in detail in Bulletin No. 51B. Send for it today.



Patented and Patents Pending

Farris

SAFETY and RELIEF VALVES

FARRIS ENGINEERING CORP.

7983 436 Commercial Avenue Palisades Park, N. J.

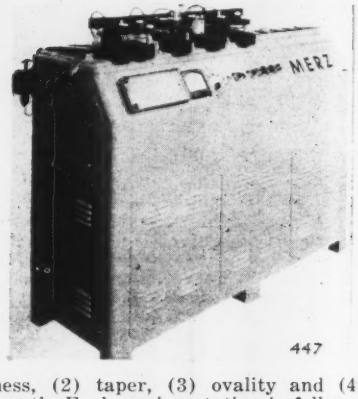
NEW INSTRUMENTS

tems at high pressures (500 to 5000 psi.) and at low flows (approx. 1 gpm. at 2000 psi.). Power is furnished by "Model S-216-C" air-operated boost pump utilizing plant air. Unit is fully equipped with pressure regulator, shut-off valve, relief valve, 4-way selector valve and all necessary instruments, controls and connecting hoses. It is available with either a single or dual outlet system. Steel cabinet is mounted on 6-in. rubber-tired wheels. Weight 165 lbs., height 44 in. including handle. —*Sprague Engineering & Sales, Gardena, Calif.*

Mention No. 818 when filling out card.

Automatic Inspector and Segregator for Tappets

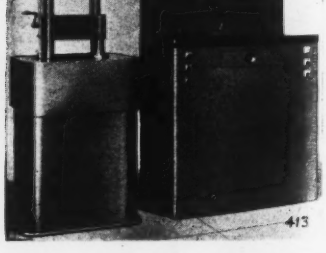
New automatic checking and segregating machine checks 2800 automotive tappets per hour for: (1) face squareness, (2) taper, (3) ovality and (4) length. Each gaging station is followed by an ejector for rejections.—*Merz Engineering Inc., 200 S. Harding St., Indianapolis, Ind.*



Mention No. 819 when filling out card.

12,000-lb. Testing Machine

New "Model 12-H" 12,000-lb. universal testing machine has many features of maker's larger machines. Space between columns is 9.5 in. Tension or compression load is applied upward by an integrated piston and elevating cage consisting of table, two uprights and upper gripping head, all of which have an 8-in. stroke. Loading speed can be varied infinitely between 0 and 10 in. per minute. Vertical distance between gripping heads: 1 in. to 21 in., latter

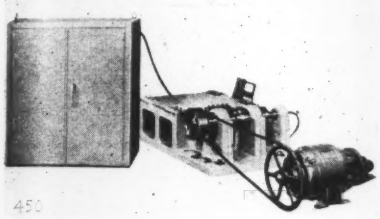


including stroke. Automatic safety devices protect gages against overloads and prevent over-travel of moving parts. Two ranges: 12,000-lb. graduated in 20-lb. units on a 16-in. diameter indicator dial; 3000-lb. in 5-lb. units. Ranges other than standard available in any dual combination.—*Baldwin-Lima-Hamilton Corp., Philadelphia 42, Penna.*

Mention No. 820 when filling out card.

Vibration Tester

New vibration-test machine subjects aviation instruments, radios, gasoline tanks, etc., to variable frequencies (600

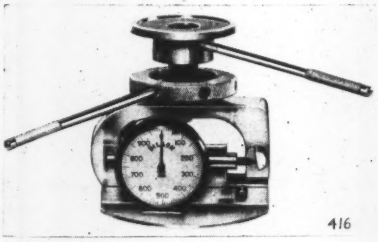


to 3600 cpm.) and variable amplitude (0 to 0.062 in.). Capacity 100 lbs.; dimensions of standard table 18 in. square.—*Vibration Specialty Co., 1536 Vine St., Philadelphia 2, Pa.*

Mention No. 821 when filling out card.

Load Gage and Jack

New Jacking Assembly is accessory for maker's mechanical pressure gage; is chiefly designed for operations where it is necessary to measure mechanical

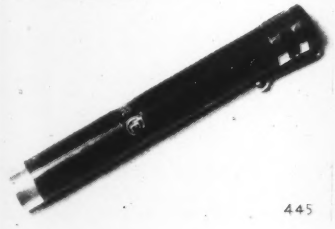


forces exerted by springs, air pressure, oil pressure valves, etc., as in sealing beer cans where spring pressure exerted by can-sealing head must be set exactly in order to create a perfect seal and prevent leakage of contents.—*W. C. Dillon & Company, Inc., 1421 S. Circle Ave., Forest Park, Ill.*

Mention No. 822 when filling out card.

Radiation Dosimeter

New "Model L-26" dosimeter has 0-200-mr. range, is 0.5 in. in diameter by 3.625 in. long; barrel of conducting



Type 5JP11A
Single-gun tube

Type 54SWP11
4-gun tube

H-21 Dual-channel Oscilloscope

Oscilloscope
for strip-film recording

ETC

...for more accurate and efficient RESEARCH, TEST and VISUAL OPERATING CONTROL

By permitting simultaneous observation or recording of 2, 4, 6 or more different phenomena, ETC multi-gun cathode ray tubes and multi-channel oscilloscopes pave the way to farther-reaching analysis and better operation in many fields.

New catalog on request.

H-81 8-Channel Oscilloscope
originally developed for recording seismographic phenomena

H-42A Strainalyzer
for simultaneous analysis of 4 stresses or strains from 0 to 50,000 cycles

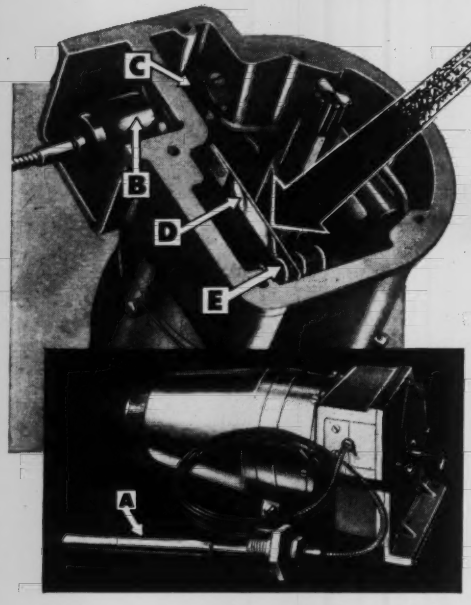
Type 21JHP7
Single-gun tube

Type 55JG
5-gun tube

electronic tube corporation
1200 E. MERMAID LANE, PHILADELPHIA 18, PA.

BARBER COLMAN

KEEPS the Diesels COOL



with

CHACE BIMETAL

The cooling of water and lubricating oil in Diesel-electric road and switching locomotives is a problem which, like death and taxes, is always with us. Barber-Colman Company engineers have licked this problem with their Type AYM Self-Contained Control Motor for regulating radiator shutters to keep coolants within desired temperature range.

Product of Barber-Colman Co. Rockford, Illinois

The DC reversible motor turns at speeds of ⅓ r.p.m. to 6 r.p.m., dependent on torque requirements. The swing of arm attached to the shaft is controlled by limit switches. Thermo Bulb A, filled with liquid, is immersed in the coolant or oil. As the temperature increases, the liquid in the bulb expands, forcing movement of a plunger in Bellows B against a contact at C. The same movement of the plunger swings the pivoted Chace Thermostatic Bimetal element D against the left hand spring contact at E which determines direction of rotation of the motor. The prime function of the thermostatic bimetal, however, is to compensate for gain or loss of heat in the capillary and bellows caused by changing ambient temperatures. As the bimetal reacts to the changing temperatures, it makes the shutter action early or late, to suit conditions.

Chace Thermostatic Bimetal No. 2400 is specified for this vital job, out of the 29 types available in strips, random coils or completely fabricated elements. Use our 64-page reference as a guide to thermostatic bimetal selection for your own temperature actuated devices but call in the Chace Application Engineers in the early stages of your design for complete information and counsel.

IT BENDS WITH THE HEAT

W. M. CHACE CO.
Thermostatic Bimetal
1609 BEARD AVE., DETROIT 9, MICH.

NEW INSTRUMENTS

laminated Bakelite; hermetically sealed. Instrument meets all standard specifications for its range. Charged on battery-operated "L-21" Charger which has no on-off switch to forget and has battery shelf life of 18 months to two years.—*Landsverk Electrometer Co., (Aff. Technical Associates), 3730 San Fernando Road, Glendale 4, Calif.*

Mention No. 823 when filling out card.

Isotope Ratemeter

New "Model 524" is a counting ratemeter of laboratory-quality for detecting and measuring alpha, beta and gama radiation. Among features: Six

ranges of sensitivity with full-scale readings from 300 to 100,000 counts per minute; three-position time-constant selector and enclosed loudspeaker for aural monitoring; provision for scintillation counter as well as adaptability for counter tubes.—*Victoreen Instrument Co., 5806 Hough Ave., Cleveland 3, Ohio.*

Mention No. 824 when filling out card.

Radiation Monitor

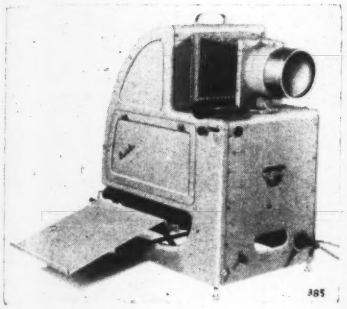
New "SU-3B" features simpler and better method of high voltage control, was developed specifically for use as a routine contamination monitor in ra-

dioactivity laboratories; has three ranges; 200, 2000, and 20,000 counts per minute. It comes with a mica end-window Geiger tube enclosed in a detachable probe assembly. Other features: built-in loud-speaker monitor at rear of the chassis; control on front panel for adjustment of volume; and ability to drive recorders with low current drain.—*Tracerlab, Inc., 130 High St., Boston 10, Mass.*

Mention No. 825 when filling out card.

Projector

New "Vu-lyte" has (1) "Vacumatic Platen" which holds all copy flat during projection. (2) "Feed-o-Matic Conveyor" belt that permits mixed or continu-

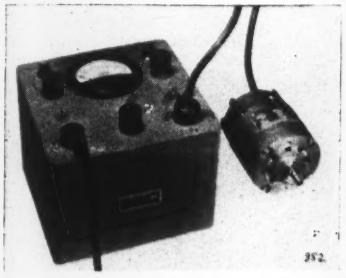


ous copy to be fed through merely by turning a handle. (3) "Pointex Projection Pointer" that permits user to throw lighted arrow onto any part of the screen. Weight is 35 lbs.—*Charles Beseler Co., 60 Badger Ave., Newark 8, N. J.*

Mention No. 826 when filling out card.

Controlled Motor

New "301-A" speed control unit consists of special motor and companion control box operating from 115-v. 60-cycle line. Combination provides finger-

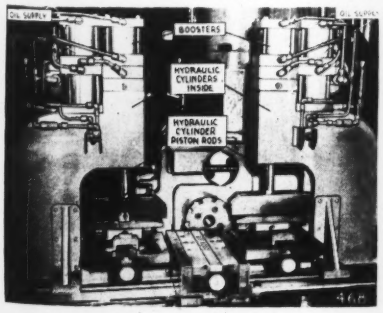


tip control of motor speed from 50 to 5000 rpm. A front panel indicator, calibrated in rpm., gives motor speed directly. Motor delivers up to 10 in.-oz. torque at any speed.—*Industrial Control Co., Wyandanch, L. I., N. Y.*

Mention No. 827 when filling out card.

Pneumatic and Hydraulic Power Unit

New "Model B4 Air Miser" permits operation of machines, etc., by 80 psi. air to produce 2000-psi. hydraulic pressure without use of hydraulic pump or

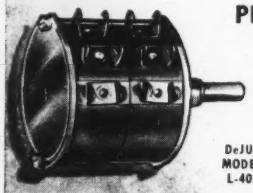


OVER 30 YEARS OF PRECISION ELECTRICAL EXPERIENCE

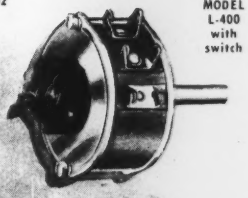
DeJUR

PRECISION *Potentiometers*

SERIES L-400



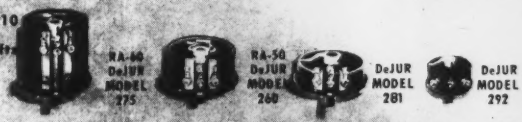
DeJUR MODEL L-402



DeJUR MODEL L-400 with switch

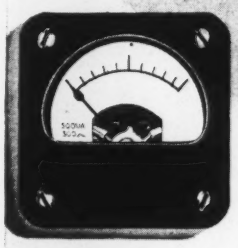
To meet the increasing demand for small compact precision potentiometers for military airborne instrumentation and similar applications, DeJUR is now producing the L-400 series potentiometers, built to rigid mechanical and electrical requirements of JAN-R-19 specifications.

FEATURES:
- 1⅜" diameter
- 3 watts fully enclosed
- 5 to 125,000 ohms
- accuracy up to 0.5%
- linearity up to 0.1%
- 300° rotation mechanical and electrical
- on-off switch
- ganging up to 10 units
- double end shafts available



RA-40 DeJUR MODEL 275 · RA-50 DeJUR MODEL 260 · DeJUR MODEL 281 · DeJUR MODEL 292

Built to JAN-R-19 specifications. Other models from 1-3/16" to 5" diameter.



DeJUR MODEL 112

1½" *Panel* INSTRUMENTS

Also available • 2½" • 3½" • 4" panel meters in all standard ranges. JAN-1-6 and A. S. A.

DeJUR MODEL 120

FEATURES:
Precision built DeJUR 1½" instruments for applications where space must be conserved • DeJUR rugged construction • Both models in all ranges and sensitivities • External shunts and multipliers available for various ranges • Complete magnetic shielding and methods of lighting scale • Approved source for government services meets JAN specifications.

- DC VOLTMETERS
- AMMETERS
- MILLIVOLT METERS
- MILLIAMMETERS
- AC RECTIFIER TYPES (self-contained).

Aluminum Case • One Hole Ring Mounting

Power RHEOSTATS

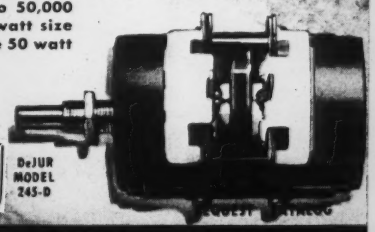
Built to JAN-R-22 specifications, DeJUR Rheostats are available in 25 or 50 watt sizes, single or dual ganged. Resistances up to 50,000 ohms in the 25 watt size and 75,000 in the 50 watt size.

DeJUR MODEL 241

All Metal Construction

DeJUR MODEL 245

For Further Information write Dept N81



DeJUR MODEL 245-D

DeJUR USA

DeJUR AMSCO CORPORATION

45-01 NORTHERN BOULEVARD, L. I. C. 1, N. Y.

MANUFACTURERS OF SCIENTIFIC PRECISION EQUIPMENT FOR OVER A QUARTER OF A CENTURY

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What LORD PRECISION in Vibration-Control means to YOU

● The precision with which molds are made accounts in part for the accuracy and uniformity of LORD Vibration-Control Mountings. For example, before the form tool which will give shape to new molds is used, it is placed in a comparator which enlarges and projects the contour of the cutting edge for direct comparison with drawings. By such modern techniques, LORD avoids errors and produces molds exactly as designed.

Similar high standards of precision guard quality at every stage of production. This is the reason why satisfaction and dependability accompany every shipment of LORD Mountings. It is also assurance that LORD Mountings will add sales appeal to your product . . . will increase customer appreciation . . . will insure extra years of smooth, quiet, effortless performance.

Booth 341
National Instrument Exhibit
Lord Engineering Representatives will be there to assist you to solve your vibration problems most efficiently and economically.

LORD MANUFACTURING COMPANY • ERIE, PA.

LORD BONDED RUBBER

Vibration-Control Mountings . . . Bonded-Rubber Parts

NEW INSTRUMENTS

high-pressure valves. Illustration shows an example, i.e., Sundstrand milling machine. Fluid pressure booster with 25:1 ratio and high-pressure hydraulic cylinder constitute one integral unit; adjacent oil tanks provide volume requirement of low-pressure approach stroke. Positioning accuracy is 0.0003 in.—*Miller Motor Co.*, 4027 *No. Kedzie Ave., Chicago* 18, *Ill.*

Mention No. 828 when filling out card.

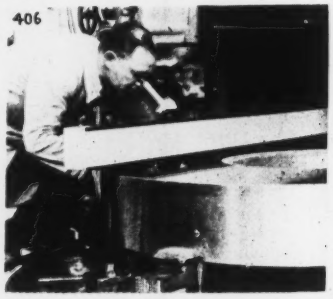
Aircraft Power Unit with Quick-disconnect Fitting

New "Model 150" Power Units and "Model 568A" Screwjacks for aircraft control systems feature a new quick-disconnect fitting, which obviates need for fastening and unfastening of safety wire at connection of flexible shafting. Field tests have shown a saving of as high as 2 hours 50 minutes in installation of an 8-screwjack system. New devices were designed for use in actuating systems requiring either 27-volt d-c. or 400-cycle a-c. reversible motors. —*Lear, Inc.*, 110 *Ionia Ave. N.W., Grand Rapids* 2, *Mich.*

Mention No. 829 when filling out card.

Optical Straightedge

New "Griswold Huet Optical Straightedge" utilizes a beam of light as a straight-line reference, permits measuring deviations of supposedly



flat surfaces as small as 0.00005 inch; consists of a lens and prism housing, and a feeler microscope with built-in illumination which rides along surface under examination. Housings are made in standard lengths of approx. 3, 5, 10 and 13 feet. Surface contours, enlarged by 1000, may be graphically recorded by accessories attached to equipment.—*F. T. Griswold Mfg. Co.*, 305 *W. Lancaster Ave., Wayne, Pa.*

Mention No. 830 when filling out card.

Combination Shut-off and Safety Valve

New "MR-5 Gas Cock Safety Valve" is a small combination safety and plug valve. Has "fail-safe" operation. Consists of thermocouple safety shut-off in "hi-flow" gas-cock valve structure. Available in pipe sizes from ⅜ in. to ¾ in. All models UL and AGA approved. —*General Controls Co.*, 801 *Allen Ave., Glendale, Calif.*

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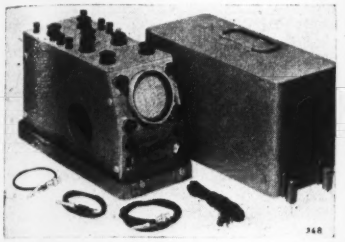
Portable Oscilloscope

New "Model 380 Miniscope" has frequency coverage to 2.5 Mc. and features: Sensitivity of 0.1 rms. volts per



inch, direct connection to CR tube elements, provision for Z-axis modulation, telescopic light shield. 6 x 9 x 13.5 inches; weighs 14 pounds.—*The Hickok Electrical Instrument Co., 10519 Dupont Ave., Cleveland 8, Ohio.*

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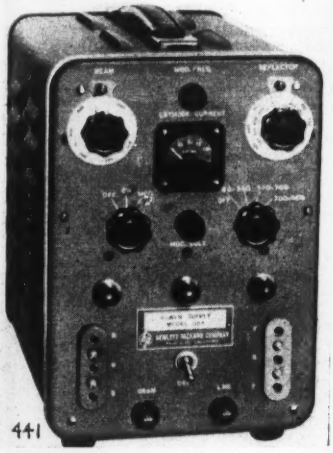
Klystron Power Supply

New "715A" power supply, for test-bench operation of low-power klystron oscillators, provides a beam voltage continuously variable from 250 to 400

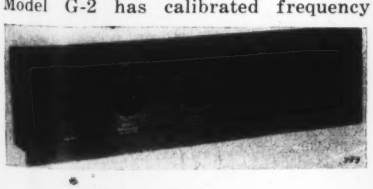


volts at 50 ma. maximum. Reflector voltage is variable from 10 to 900 volts at 5 ua. Instrument also provides for square-wave modulation at 1,000 cps.; may be modulated from an external source; gives a filament supply of 6.3 volts at 1.5 amps.—*Hewlett-Packard Co., 395 Page Mill Road, Palo Alto, Calif.*

Mention No. 833 when filling out card.

Panoramic Indicator

New "Model G2 Sonic Response Indicator" is used as adjunct to "Panoramic Sonic Analyzer Model AP-1," which indicates fundamental frequencies only—the generated frequency and the AP-1 scan being in synchronism. Model G-2 has calibrated frequency



Edin instruments

OSCILLOGRAPH GALVANOMETER

No's. 8001, 8002, 8003 and 8004 ink-writing galvanometers have sensitivities from 3.5 to 40 volts per cm., resonant frequencies from 15 to 120 cps., resistances from 1000 to 2000 ohms, frequency response up to 350 cps., and a single-jewel pivot construction. Units are designed for multiple operation up to 10 channels in a total width of 12 inches.

DIRECT-COUPLED AMPLIFIER

No. 8100 direct coupled amplifier has a voltage amplification of 13,000 with a maximum output of 70 volts. Frequency response from d.c. to 10,000 cps. is flat within 10%. Input impedance is 2 megohms; output impedance is 150 ohms. Input may range from 0.1 mv. to 100 volts. Stability is better than 0.1 mv. per thirty minutes, or 0.5 mv. per day. Attenuator is stepped for factors from 1 to 1000.

OSCILLOGRAPHS

Recorders can be supplied with 1, 3 or 9 chart speeds ranging from 0.1 mm./sec. to 250 mm./sec. See specifications of OSCILLOGRAPH GALVANOMETER for frequency range.

OSCILLOGRAPH AMPLIFIER

No. 8121 special amplifier has a time constant of 1 second, an exponential response to a square wave at high gain, input impedance of 1 megohm, and input form 0.1 mv. to 1000 volts. At low gain, No. 8121 becomes a DC amplifier with a voltage gain of 100 and an input of 10 mv./mm.

HIGH-GAIN AMPLIFIER

No. 8130 amplifier has a voltage gain of 1,000,000 and includes a built-in pre-amplifier. Frequency response is from 1 to 200 cps. Input may range from 10 microvolts to 100 millivolts. This amplifier is particularly suited for Biological studies.

Many other types of recording and amplifier circuits are available and special equipment can be assembled to meet particular specifications.

EDIN COMPANY, INC.
207 Main Street
Worcester 8, Mass.

Please send complete information on:

☐ RECORDERS
☐ NO. 8121 AMPLIFIER
☐ GALVANOMETERS
☐ No. 8100 AMPLIFIER
☐ No. 8130 AMPLIFIER
☐ ..... SPECIAL (Enclose details)

..... (NAME)

..... (NO.) (STREET)

..... (CITY) (STATE)

..... COMPANY POSITION

What LORD PRECISION in Vibration-Control means to YOU

● The precision with which molds are made accounts in part for the accuracy and uniformity of LORD Vibration-Control Mountings. For example, before the form tool which will give shape to new molds is used, it is placed in a comparator which enlarges and projects the contour of the cutting edge for direct comparison with drawings. By such modern techniques, LORD avoids errors and produces molds exactly as designed.

Similar high standards of precision guard quality at every stage of production. This is the reason why satisfaction and dependability accompany every shipment of LORD Mountings. It is also assurance that LORD Mountings will add sales appeal to your product . . . will increase customer appreciation . . . will insure extra years of smooth, quiet, effortless performance.

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Lord Engineering Representatives will be there to assist you to solve your vibration problems most efficiently and economically.

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LORD BONDED RUBBER

Vibration-Control Mountings . . . Bonded-Rubber Parts

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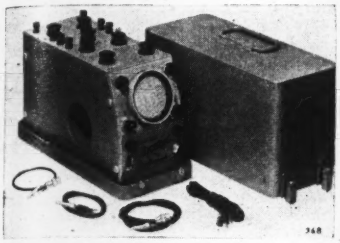

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..... (CITY) ..... (STATE)

..... COMPANY ..... POSITION

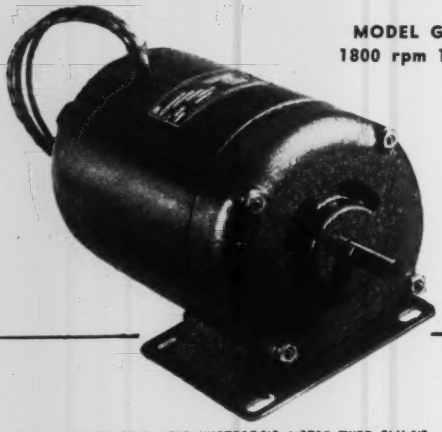
Stabilized

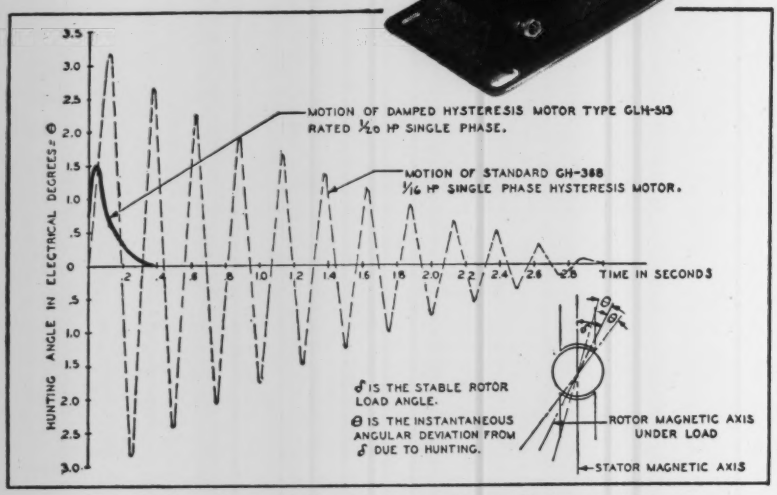
•HYSTERESIS MOTOR

NON-HUNTING

FULLY-DAMPED
MOTION
FOR
LARGE
INERTIA
LOADS

MODEL GL 513
1800 rpm 1/20 hp




HUNTING ANGLE IN ELECTRICAL DEGREES = θ
MOTION OF DAMPED HYSTERESIS MOTOR TYPE GLH-513 RATED 1/20 HP SINGLE PHASE.
MOTION OF STANDARD GH-368 1/16 HP SINGLE PHASE HYSTERESIS MOTOR.
TIME IN SECONDS
δ IS THE STABLE ROTOR LOAD ANGLE.
θ IS THE INSTANTANEOUS ANGULAR DEVIATION FROM δ DUE TO HUNTING.
ROTOR MAGNETIC AXIS UNDER LOAD
STATOR MAGNETIC AXIS

Approximate motion curves for standard and damped hysteresis with load inertia of 100 ounce—(inches)² by weight, rotating 1800 rpm.

THE new Model GL 513 Elinco motor is excellent for all sound and optical work, for goniometer drives, and all other applications where a high degree of motional stability is essential. It permits higher basic motor speeds for a given load inertia without increase in flutter . . . allowing greater power output for fixed motor size.

The curves compare a standard 1/16 hp hysteresis motor with the new GL 513: note that the non-hunting motor not only radically reduces the **duration** of any oscillation, but also cuts the **magnitude** of the initial swing about 50%. Furthermore, whereas the standard motor, after one oscillation, damps out a connected load of only 9 oz.in.² by weight, the GL 513 shows a value of 180 oz.in.²

Model GL 513 is currently available for reasonable future delivery; other stabilized units, with other speed and voltage ratings as well as multiple-speed units, are under development.

ELINCO

ELECTRIC INDICATOR CO.

PARKER AVENUE • STAMFORD, CONN.

MANUFACTURERS OF SPECIALLY-DESIGNED PRECISION MOTORS AND GENERATORS-GOVERNOR-CONTROLLED: SELF-SYNCHRONOUS; DRAG-CUP: DC & AC TACHOMETER; SHUNT; SERIES; COMPOUND; PERMANENT-MAGNET; SPLIT-FIELD; SEPARATELY-EXCITED; UNIVERSAL; INDUCTION; RELUCTANCE; HYSTERESIS; DC & AC SERVO; REELMOTORS; TOTALLY-ENCLOSED; AC DYNAMICALLY-BRAKED; MULTIPLE-SPEED.

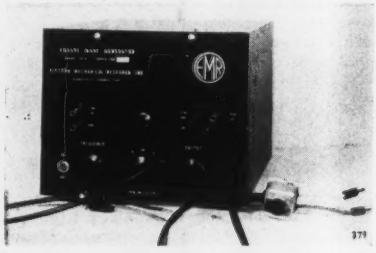
NEW INSTRUMENTS

scale, linear or logarithmic (40-db. range) amplitude scale, high sensitivity (500 uv. for full-scale deflection), logarithmic frequency sweep, and 1-cps. sweep rate.—*Panoramic Radio Products, Inc., 10 South Second Ave., Mt. Vernon, New York.*

Mention No. 834 when filling out card.

Square-wave Generator

New "Model 43A" square-wave generator has variable-frequency multivibrator which drives two-stage clipper circuit to produce 24-volt negative-going square waves. No external driving voltage required. Synchronizing input circuit allows generator to be operated synchronously with other equipment. Separate output sync signal for triggering purposes. Continuously variable attenuator has range of 24 db. Step attenuator has 20-, 40-, and 60-db. steps. Frequency range is 6 to 1,000,000 cps. Rise time is approximately 0.03 microseconds above 90 kc.—*Electro-Mechanical Research, Inc., Ridgefield, Conn.*



Mention No. 835 when filling out card.

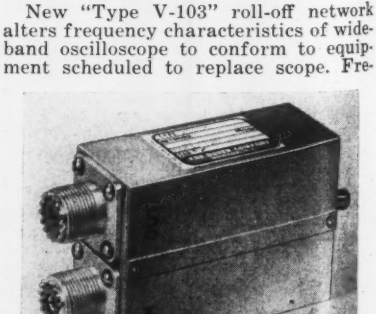
12-in. Cathode-ray Tube

New "12SP7" is a 12-inch directly-viewed cathode-ray tube of magnetic-focus and magnetic-deflection type intended primarily for radar indicator service, but also useful in general oscillographic applications where a temporary record of electrical phenomena is desired. It utilizes long-persistence cascade phosphor P7. Almost-flat faceplate is made of "Filterglass," facilitates use of transparent calibrated scale.—*Tube Dep't, Radio Corporation of America, Harrison, N. J.*

Mention No. 836 when filling out card.

Video Roll-off Network

New "Type V-103" roll-off network alters frequency characteristics of wide-band oscilloscope to conform to equipment scheduled to replace scope. Fre-

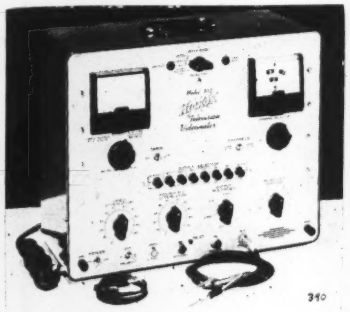


quency characteristic provides 6-db. roll-off at three megacycles with reference to low frequencies. Circuit provides rise time of approximately 0.175 microseconds without overshoot. Circuit is three-mesh 73-ohm constant-impedance network.—*Daven Co.*, 191 *Central Ave., Newark* 4, *N. J.*

Mention No. 837 when filling out card.

Video Generator

New "Model 650 Television Videometer" is crystal controlled and has r-f. output directly calibrated in micro-

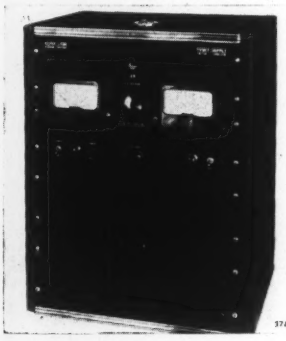


volts for TV receiver sensitivity checks. Line-voltage scale checks fluctuation. Produces horizontal and vertical sawtooth voltages.—*Hickok Electrical Instrument Co.*, 10519 *Dupont Ave., Cleveland* 8, *Ohio.*

Mention No. 838 when filling out card.

Regulated Power Supply

New "Model 1250" regulated high-voltage power supply is continuously variable from 200 to 1000 v. and delivers from 0 to 500 ma. Voltage vari-



ation is less than 0.5 percent for line fluctuations from 105 to 125 v. and for load variation from 0 to 500 ma. Ripple is less than 20 millivolts. Supply includes fuses, time-delay relay, and overload relay. Weight is 167 lbs.—*Kepco Laboratories, Inc.*, 149-14 41*st Ave., Flushing, N. Y.*

Mention No. 839 when filling out card.

Flame Failure Safeguard

New series of "Fireye Flame Failure Safeguards and Programming Controls" includes "Series FP Controls," which have photoelectric flame failure safeguard. Photoconductive cell "sees" flames and responds to flame failure. Installed in 0.5-in. standard pipe. Scanner and control can monitor complete

U. S. Army Quartermaster Corps Research and Development Laboratories at Philadelphia take their STORAGE TEST PROBLEMS to Tenney

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Long-term storage of almost countless types of military supplies—*without deterioration,* is no small problem.

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For all types of testing—development, research, specification, and production—a Tenney-engineered chamber will meet *your* requirements. For testing under all degrees of humidity, at all altitudes and temperatures, a Tenney-built test chamber assures complete dependability and precisely controlled test data. Automatic cycling, indicating, and/or recording systems to your specifications, if desired.

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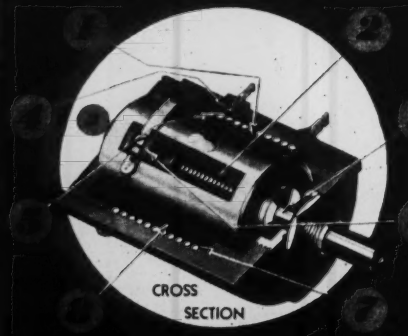
1. You get permanent accuracy because the resistance wire is locked in place. It is precision positioned and moulded integrally with the housing.
2. You get permanently accurate settings, smooth action and low uniform torque provided by the stainless steel, precision ground, double thread lead screw guiding the moving contact.
3. You get precise positioning of the moving contact because of the two bearings supporting the rotor assembly.
4. You get good rigid terminals because they are moulded integrally with the housing.
5. Terminals soldered to ends of resistance element before moulding. Entire resistance circuit is an integral part of the housing.
6. You get accurate setting and resetting due to anti-backlash spring in contact guide.
7. You get a fine resolution because of the 43½" length of resistance wire in the spiral element.
8. You get a resistance output directly proportional to shaft rotation within ±0.1% of the total resistance. Every potentiometer is automatically machine tested for linearity at 101 points.



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Units for immediate shipment:
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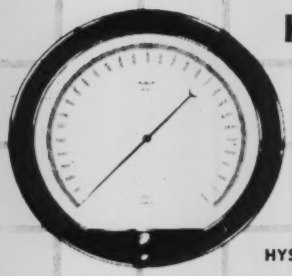

HEISE GAUGES

now used for
PVT determination

TIGHT AGAINST MERCURY
HYSTERESIS LESS THAN ½ OF 1%
CONSTANT READING THROUGHOUT TEST
SENSITIVE TO SLIGHT CHANGES IN PRESSURE

In repeated applications, Heise Bourdon Gauges have more than met the exacting requirements of PVT analysis. Exclusive Bourdon tube design and precision ball bearing movement provide inherent stability and accuracy throughout the pressure range.

Heise Gauges are used in many industries for precise measurements of pressure. Custom-built in pressure ranges from 0-15 to 0-10,000 psi. Sizes: 8½", 12", and 16" diameter. Standard gauges from $151.60 to $211.20. Gauges for use with mercury are $20.00 extra. Write for catalog.

Heise Bourdon Tube Company, Inc.
Newtown, Connecticut

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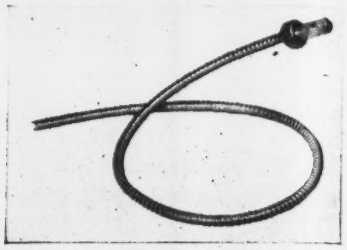
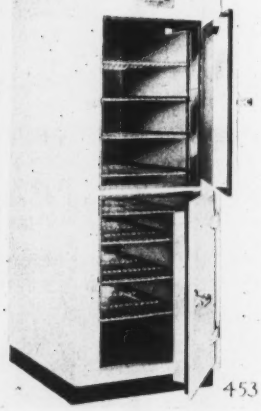


firing cycle. Meets requirements of Underwriters' and Factory Mutual Laboratories. Timing is by synchronous motor.—*Combustion Control Corp., 77 Broadway, Cambridge 42, Mass.*

Mention No. 840 when filling out card.

Controlled Temperature and Humidity Cabinet

New "Model LSC-16 Laboratory Cabinet" features a fully-automatic conditioning unit with self-contained water feeder for 2200-watt humidity



generator and for wet-bulb thermometer and controller; balanced multivane aluminum blower and stainless scroll; 1800-watt nichrome heater; temperature range to 160 F.; humidity to 95 percent. Interior dimensions, 18.12 in. wide by 27.25 in. deep by 57.5 in. high.—*Anetsberger Bros., Inc., 180 N. Anets Drive, Northbrook, Illinois.*

Mention No. 841 when filling out card.

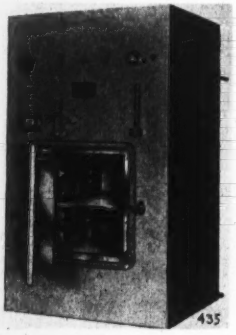
Thermoscopic Paint

New addition to maker's "Tempilaq" liquids extends upper range of series from 1950 F. to 2000 F.—*Tempil Corp., 132 W. 22nd St., New York City.*

Mention No. 842 when filling out card.

Thermostated Oven

New "Model 1304" table model mechanically-convected oven with automatic temperature control uses a minimum of table space. Chamber is 12 in.

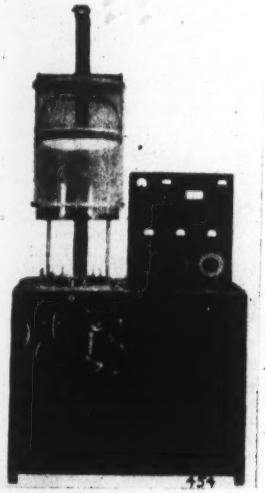


wide x 14 in. deep x 14 in. high, but exterior dimensions are 23 in. wide x 20 in. deep x 40 in. high. Floor of the chamber is 9 in. above table. Temperature range is from 35 C. to 180 C. with a temperature differential of ±0.5 C. Adjustable hydraulic control thermostat; "Limitstat" over-temperature thermal switch; and built-in thermometer set at eye level.—*Electric Hotpack Co., 5029 Cottman Ave., Philadelphia 35, Pa.*

Mention No. 843 when filling out card.

High-vacuum Evaporator

New "R-2" high-vacuum evaporator has high-speed diffusion pump and 26-cmf. mechanical pump; has been developed for lens coating, aluminizing



and research. Unit weighs about 1,000 lbs.; is guaranteed to produce a vacuum of 10^{-4} mm. of mercury within about five minutes and 0.05 micron within 15 minutes. Lower pressures after longer pumping.—*Optical Film Engineering Co., 2737 N. 6th St., Philadelphia 33, Pa.*

Mention No. 844 when filling out card.

Multi-point Tachometer

New "Series 42" indicating tachometer incorporates a selector switch for quick intercomparisons of speeds of machines which may be located up to

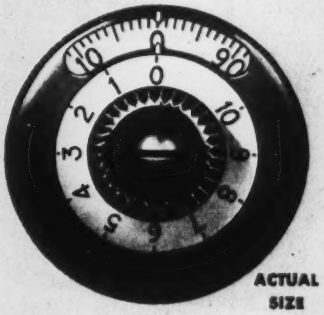
MICRODIAL
TEN TURN-COUNTING DIAL

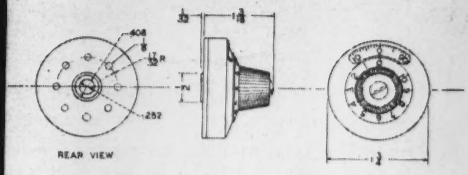
Microdial is composed of two concentrically mounted dials . . . one for counting increments of each turn and the other for counting turns. The incremental dial has 100 equal divisions and is attached rigidly to the shaft so there is no backlash. Thus the contact position is indicated to an indexed accuracy of 1 part in 1000. Rotation is continuous in either direction. There are no stops on the Microdial assembly.

COMPACT . . . Microdial has same O.D. as Micropot . . . requires no more panel space.

CLEAR READING . . . Forced fast-reading tests showed only 1/20th as many errors with Microdial open window as with next most legible dial. Turn counter distinguishes between 0 and 10 turn readings, and accelerates to avoid confusion on readings near integral turns. Precise readings are made from larger dial with maximum separation of graduations and wide angle visibility.

CONVENIENT . . . delivered completely assembled with dials synchronized. Easily mounted in a few seconds. All dials may be locked.

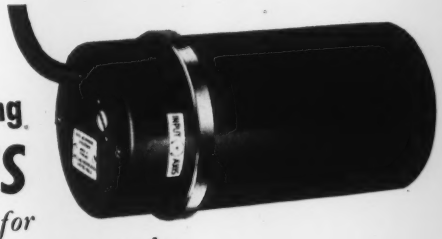




Microdial . . . turn-counting dial, primarily designed for use on Micropot ten turn linear potentiometers . . . use it on any multiturn device having ten turns or less.

BORG EQUIPMENT DIVISION
THE GEORGE W. BORG CORPORATION
JANESVILLE • WISCONSIN

Rate Measuring
GYROSCOPES
for



Control
Stabilization
Flight Testing
Rate Computation

For the accurate measurement of absolute rates of angular rotation, the Doelcam Model K Rate Measuring Gyroscope offers the following features:

1. Accuracy: 0.5%
2. Resolution: 0.1%
3. Maximum uncertainty: 0.2%
4. Hermetically sealed
5. Shock and vibration resistant
6. Microsyn pickoff: 60 — 5,000 cps
7. Thermostatically controlled damping ratio
8. Small size: 3 inches diameter x 5.82 inches
9. Lightweight: 3 5/8 lbs.

The design of the Model K Gyroscope affords wide latitude in the adjustment of parameters and permits design to any particular specifications.

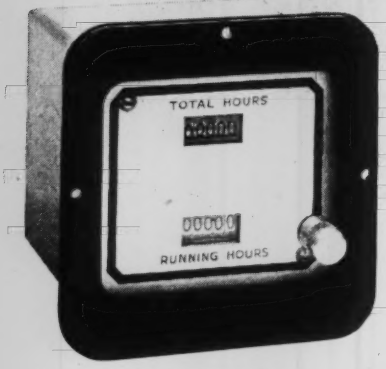
For complete details write for Bulletin K

DOELCAM CORPORATION 56 Elmwood Street Newton 58, Massachusetts

GYROSCOPIC FLIGHT TEST AND CONTROL INSTRUMENTATION

SYNCHROS · SERVOMECHANISMS · MICROSYNS · ELECTRONIC INVERTERS

RUNNING HOURS METER



Separate counters register total hours and hours since reset.

3½" x 3½" x 3" LIST PRICE $29.95

This accurate, totally enclosed, dustproof electrical indicator registers to 9999.9 hours on two counters. Knurled knob on instrument face resets lower counter to any figure as desired. High torque synchronous motor. Permanently lubricated. Uses 4 watts 115 volt 60 cycle AC. Immediate delivery. Order now.

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INSTRUMENT DIVISION
BARTLESVILLE OKLAHOMA

Phillips 66

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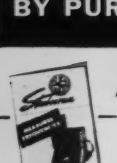
PRECISION STROBOSCOPIC FREQUENCY METER

MEASURES FREQUENCIES INSTANTLY BY PURELY VISUAL MEANS!

ACCURATE TO 0.05%



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Send me descriptive literature on NEW 6T-4 STROBOCONN.

Name .....

Street .....

City ..... State .....

Measures transient vibrations. Finds precise speed of rotating mechanical parts. Calibrates or checks precision tachometers, oscillators, other pulse generators. Used in place of bridge methods in measuring inductance and capacitance. Many other uses.

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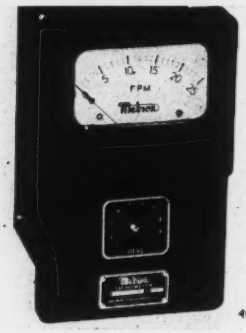
NEW INSTRUMENTS



1000 feet away from observer's station. More than 50 standard ranges, marked "RPM," "FPM," "LOAVES/HR," etc., representing any speeds between 0.1 and 100,000 rpm. Connections are made by ordinary electric wiring. Instrument is mounted on sponge rubber. Initial factory calibration may be adjusted when desired. Overspeeding does not damage electric indicator.—*Metron Instrument Co., 432 Lincoln St., Denver 9, Colo.*

Mention No. 845 when filling out card.

Speedometer-odometer for Farm Tractors

New combination instrument which can be easily installed on any tractor and measures both speed and distance traveled, without adjustment for gear ratios, tire sizes, etc., is said to make possible accurate dosage in spraying,

proper distribution in seeding, and maximum yield in harvesting. Kit contains speedometer head, nine-foot flexible shaft, mounting clamp, and support rod and drive assembly. Speedometer indicates speeds up to 10 mph.; odometer records distance up to 10,000 miles. —*Instrument Div., Stewart-Warner Corp., 1826 Diversey Pkwy, Chicago 14, Ill.*

Mention No. 846 when filling out card.

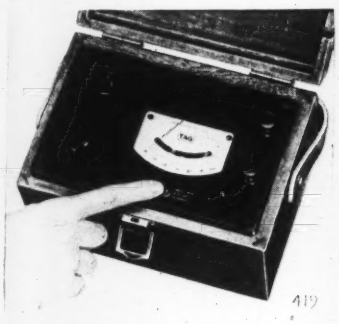
Gallons Content Nomograph

New nomograph permits rapid and accurate determination of gallons content of 55-gallon shipping containers. It is fabricated from 18-gage aluminum; dimensions 18½ by 21 inches. Each chart is furnished with a clear plastic strip which carries an accurately machined hairline.—*Gardner Laboratory, Inc., 4723 Elm St., Bethesda, Md.*

Mention No. 847 when filling out card.

Grain Moisture Meter

New model of "TAG-Heppenstall Moisture Meter for Grain" has a damping mechanism which overcomes excessive galvanometer fluctuations due

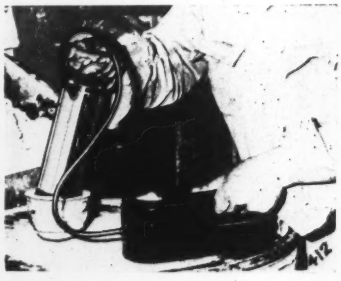


to non-uniformity of samples and permits easier reading of scale. Operated by pressing a button, new mechanism reduces pointer oscillations even under conditions of extreme variation in moisture content in a sample.—*Tagliabue Instruments Div., Weston Electrical Instrument Corp.* 614 *Frelinghuysen Ave., Newark* 5, *N. J.*

Mention No. 848 when filling out card.

Wood-waste Moisture Meter

New "Model PD 1" is specifically designed for testing wood flour, wood shavings, wood chips, sawdust and similar by-products. High-frequency



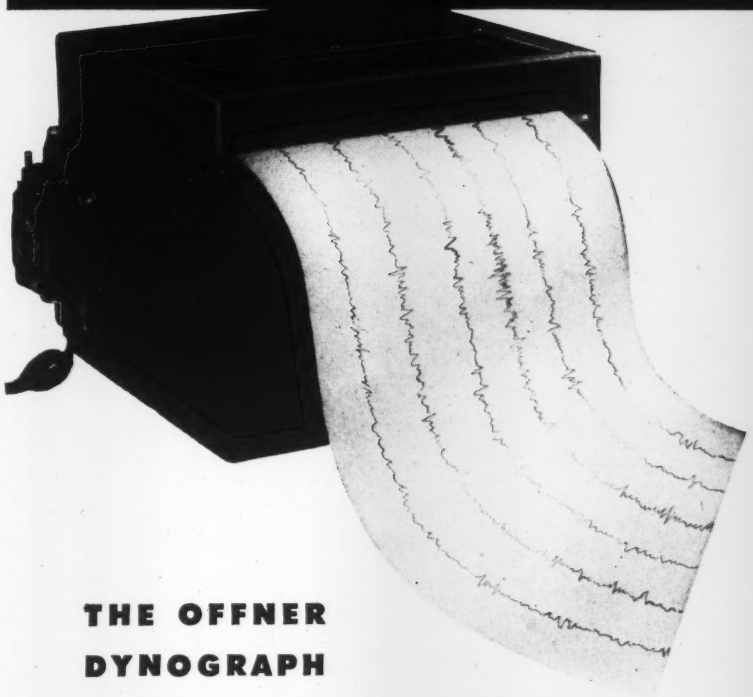
power absorption principle permits accurate testings to zero percent moisture. Instrument has a penetration of 3 in., is operated by pressure of gun electrode against a sample of the material (preferably placed in a small container), and one reading only is required to determine moisture content. —*Moisture Register Co.,* 1510 *W. Chestnut St., Alhambra, Calif.*

Mention No. 849 when filling out card.

Power Transformer Winding Temperature Indicators

New line of winding temperature equipment for power transformers consists of "Type AWR" Hotspot Indicator-Relay; "Type AW" Hotspot Indicator for local indication; and "Type AW-400" Hotspot Indicator for remote indication. All of these can be removed and tested without de-energizing the transformer, lowering oil level, or in any way interfering with operation of transformer. Units are installed in a standard liquid-tight well in side of transformer tank just below minimum liquid level. Maker's top-liquid temperature indicators for local and remote

drift-free d.c. recording



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Here's a direct writing, high speed oscillograph with microvolt d-c sensitivity—made completely drift-free through an exclusive chopper type amplifier. Now you can obtain a precise record of transient variables—some formerly recorded only by photographic means—at about 100 times the speed of other recorders with comparable sensitivity.

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Pen Deflection Linearity at 1% with pen response of 1/120th second.

Sensitivity of 150 microvolts d-c per centimeter of pen deflection.

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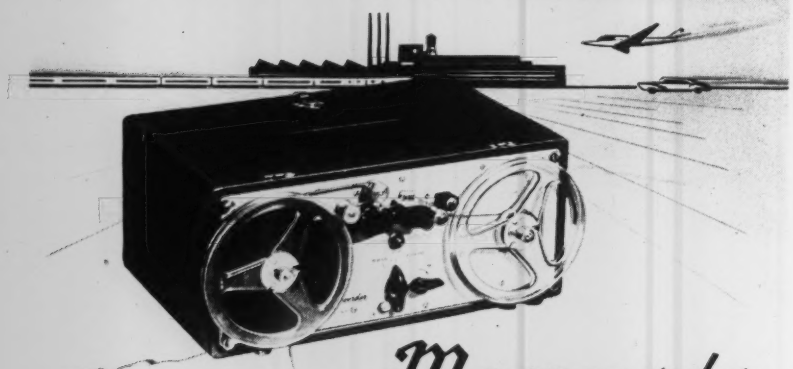

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New Burgess A.M. Power Unit

A. M. Units are packed dry and activated with water . . . once activated they may be efficiently discharged at temperatures as low as −60°F. and as high as +150°F.! Write Dept. AM for full information on standard and special types.

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So light its weight is hardly noticeable. Outperforms any iron of equal size. Hatchet design makes it more comfortable and practical to use than a pencil iron. No transformer required. Write for complete catalog.

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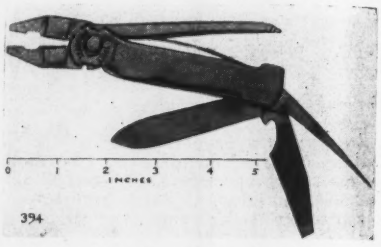
NEW INSTRUMENTS

indication have also been redesigned to fit into same size liquid-tight well as new "Hotspot" temperature devices. —*Transformer and Allied Products Div., General Electric Co., Schenectady 5, N. Y.*

Mention No. 850 when filling out card.

Instrument Man's Pocket Tool

New combination tool, manufactured in France, includes: pliers, screw driver, opener, knives, wire cutter, file

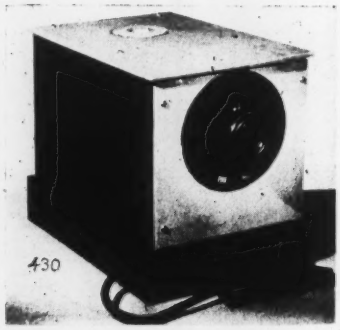


and punch; is made of high-grade steel, nickel-plated. Comes with leather case.—*The Emil Greiner Co., 20-26 North Moore St., New York City.*

Mention No. 851 when filling out card.

Instrument-shop Solder-pot

New "Hi-Temp Dipping Pot" is a silver brazing self-contained solder pot whose crucible will not crack when



heat is turned off. It operates on 117 volts a.c.; brazes Formvar or enamel-insulated wires without prestripping or pre-cleaning; is designed for high-temperature silver solder or 50-50 lead solder dipping applications.—*Tartakstolle Electronics, Inc., 3970 South Grand Avenue, Los Angeles 37, Calif.*

Mention No. 852 when filling out card.

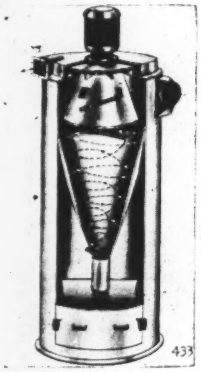
Antenna Distribution System

New "No. 1560" master antenna distribution system amplifier provides a full watt of power output, employs three 6AK5 tubes in double-tuned circuits feeding grounded grid output stage. Strips come tuned for any one of the 12 TV channels, or FM broadcast band. Up to 100 receivers may be fed from one such strip using inexpensive, non-powered isolation boxes.—*Technical Appliance Corporation, Sherburne, N. Y.*

Mention No. 853 when filling out card.

Shop Dust Eliminator

New unit dust controller is designed to operate as an independent unit where a central dust control system is not feasible, as in an instrument



shop. It operates at 6 inches external static pressure, and fan can be discharged at any 45-degree interval. Units are available in four sizes from 500 to 2000 cfm., can be furnished with or without secondary filters.—*The Day Company, 810 Third Ave. NE, Minneapolis 13, Minn.*

Mention No. 854 when filling out card.

Photoelectric Alarm

New "Photoelectric Intrusion Alarm Set P1A" provides protecting wall of invisible infrared light acros any space up to 50 feet. Consists of "Photoelec-

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done WITH NO MENTAL HAZARDS. The SCLEROSCOPE has done it for the past 42 years.

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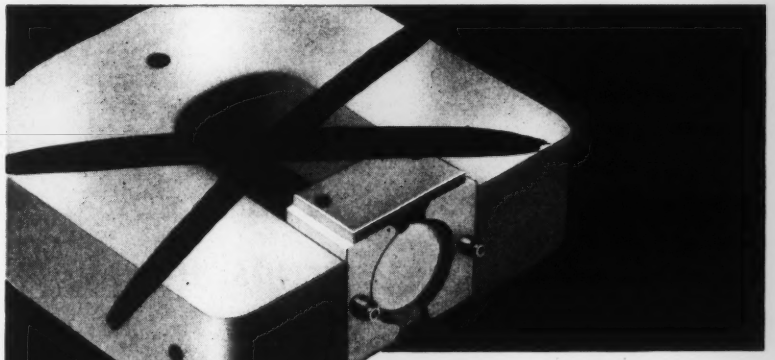
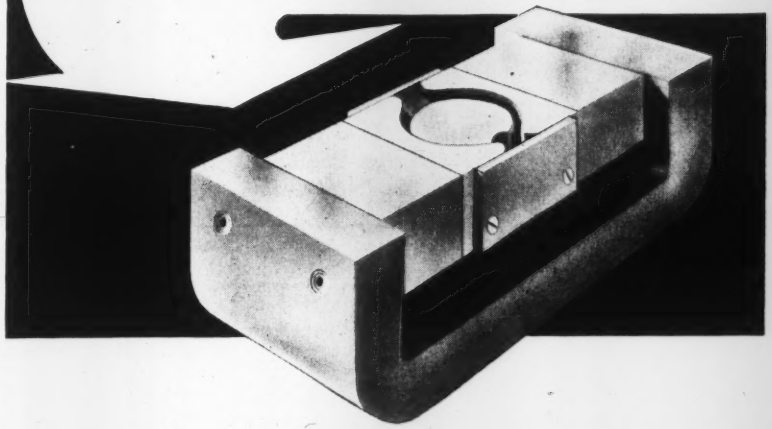


Half the Weight and 30% More Efficient



Before Thomas and Skinner Engineers were called in by Associated Research, Inc., to redesign the permanent magnet assembly for the Keeler Polygraph, commonly called the "lie detector," the magnetic unit weighed a total of 5.57 pounds.

After redesigning, the unit ***weighed only 2.93 pounds***— with the bonus of 30% more gauss in the air gap.

The compact, weight-saving unit engineered by Thomas and Skinner consists of .58 pounds of Alnico V, 1.82 pounds of iron circuit and 0.47 pounds of pole pieces . . . compared with the old assembly of 5.10 pounds of Alnico I and 0.47 pounds of pole pieces.

This material saving, space saving application is typical of the permanent magnets designed by Thomas and Skinner. Behind every recommendation is the accumulated experience of 50 years of specialization in problems of this type—a half century of designing, engineering and producing magnetic units.

Call in Thomas and Skinner for a review of your permanent magnet applications.

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FOR LINEAR CONVERSION OF WEIGHT INTO POUNDS PER SQUARE INCH AIR PRESSURE

A complete line of weight transmitters in single and multiple diaphragm construction with load capacities up to 23,000 pounds per diaphragm. Pneumatic tare balance for any portion of the total load on all models. All moving parts are enclosed totally. Complete weighing systems designed to your requirements.

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- **INPUT:** 105 to 125 VAC. 50-60 cy
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- **RIPPLE OUTPUT:** Less than 10 millivolts rms

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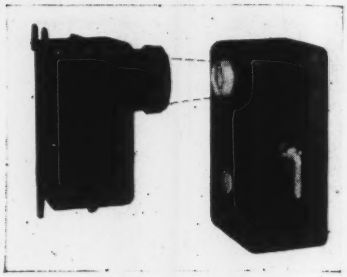

tric Control Type A20C-2" and "Light Source Type L60B." Alarm can be silenced only by restoring electric circuit by manual or automatic reset switch. Tamper-proof sensitivity adjustment.—*Photoswitch, Inc., 77 Broadway, Cambridge 42, Mass.*

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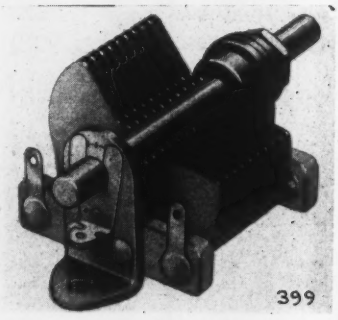
Variable Capacitor

New "Type R" variable capacitor has brass plates 0.0225 in. thick, with corrosion-resistant bright-alloy plating. Standard spacing is ordinarily 0.0245



in. for maximum capacitance ranges up to 325 mmf. Other spacings up to 0.0715 in. can be made. Dimensions are 1-5/8 in wide. by 1-11/16 in. high (plates extended).—*E. F. Johnson Co., Waseca, Minnesota.*

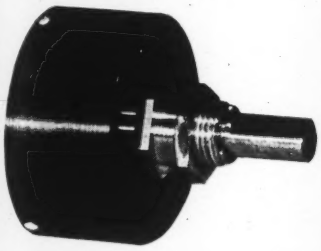
Mention No. 856 when filling out card.

Label Tape

New pressure-sensitive tape requires no moistening and is waterproof, oilproof, acid-resistant, and retains legibility from –40 F. to 150 F. Made of two layers of acetate with a white waxy substance laminated between. Pressure on clear top layer indents white waxy layer and exposes bottom

-COLE-

Precision Potentiometers



Available in various types and sizes in single and multiple units in linear and non-linear characteristics and in a wide range of resistance values.

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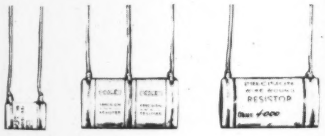

Subminiature, miniature, standard and special types.

High stability and accuracy.

Furnished in all resistance tolerances, wound with various types of resistance wire and with all types of impregnation and treatments.

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Supplied to specifications in wide limits of configurations and sizes, to extremely close electrical and mechanical tolerances.

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Graduate Mechanical, Electrical or Chemical, with several years industrial instrumentation experience for positions as Project Engineers handling design, purchase, and engineering on prefabricated process control panels. Unusual opportunity for men able to work on several projects and meet schedules. Interesting work with manufacturer of quality equipment. Location—Chicago, Illinois or Wilmington, Delaware. All replies confidential.

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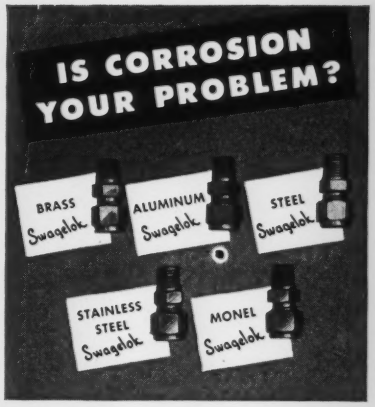

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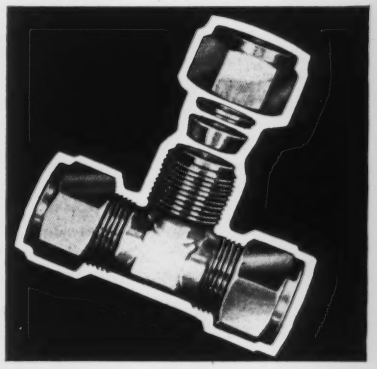

When you make every tube connection a Swagelok connection you relieve yourself of bothersome small leaks in instrumentation lines. In addition, by standardizing on Swagelok fittings inventories are reduced and control simplified, component parts are interchangeable and tube connections are made faster and easier. Swagelok fittings form a leakproof, torque-free seal with one and one quarter turns.

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Oscillograph Recorder

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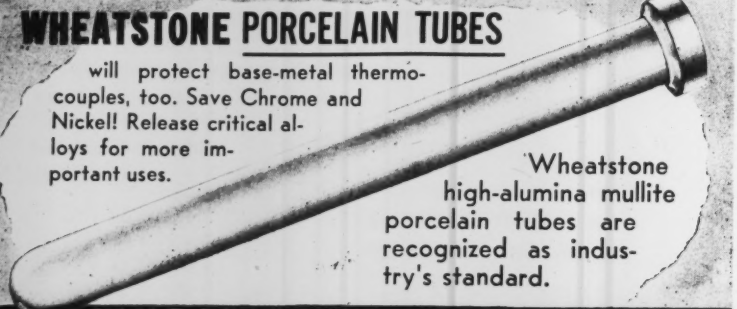

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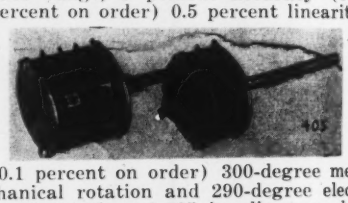

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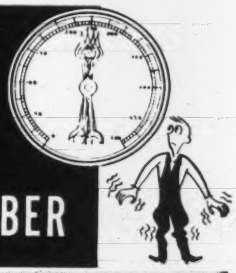

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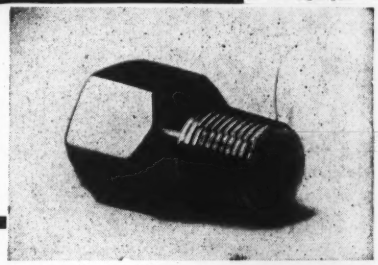

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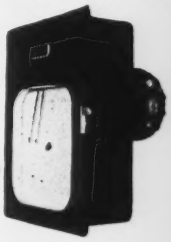

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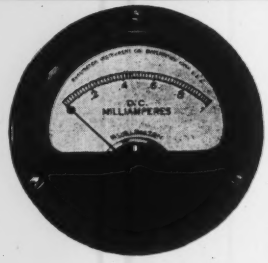

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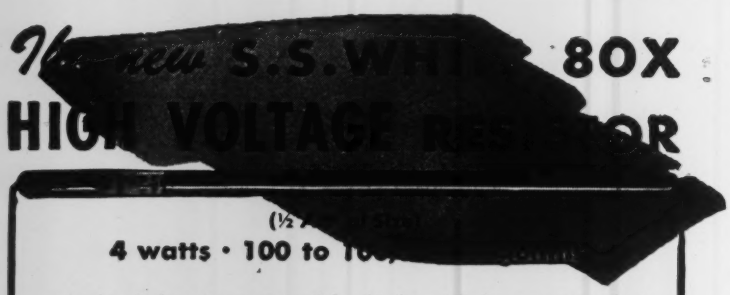

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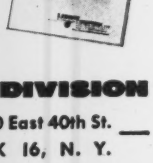

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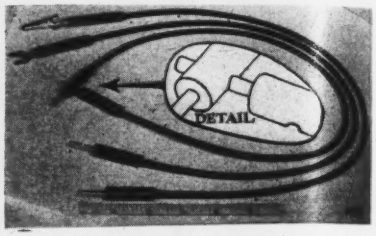

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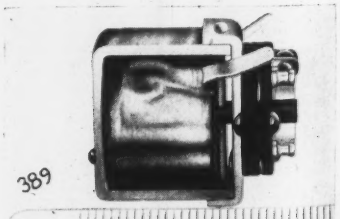

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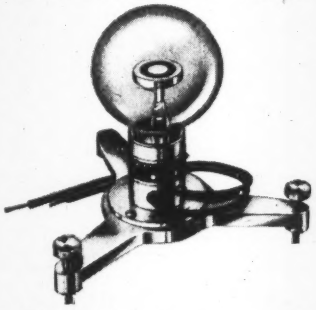

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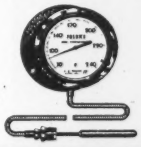

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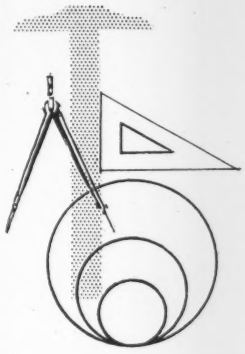

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Instrument Electronics

Continued from page 890

lines of force than is air. The ratio of the number of electric lines of force established in a dielectric material to the number of lines of force established in air is called the *dielectric constant* of the material. If we consider air as having a constant of 1, the dielectric constant of mica is about 6, and that of oil about 2. The letter K represents the dielectric constant in equations involving capacitance.

Units of Capacitance

Capacitance is the property of a capacitor to allow current to flow when the voltage across it changes. Capacitance is measured in *farads*, named after Michael Faraday, an English physicist. A capacitor has a capacitance of 1 farad when a *change* of 1 volt per second across it produces a current of 1 ampere through it. The farad is too large a unit to be used for practical purposes. In electronic equipments, the units of capacity generally used are the microfarad (uf.) and the micromicrofarad (uuf.). A microfarad is one-millionth of a farad; a micromicrofarad is one-millionth of a microfarad.

Capacitance can be defined also in terms of the total electric charge which the capacitor holds when charged to a given potential. The capacitance of a capacitor is similar to the volume of a storage tank. The amount of liquid you can store in a tank depends on the size of the tank. The amount of electric charge you can store in a capacitor depends on three factors—the area of the metal plates, the thinness of the dielectric, and the nature of the dielectric, as shown by the formula for the capacitance of a parallel-plate capacitor:

$$C = 0.224KA/d,$$

where C equals the capacitance in microfarads, K equals the dielectric constant of the material used, A equals the area of one plate in square inches, and d equals the distance between plates in inches.

Voltage Rating

In selecting or substituting a capacitor for a particular job in a circuit, you must consider (1) the value of capacitance desired and (2) the amount of voltage to which the capacitor is subjected. If the voltage applied *across* a capacitor is too great, the insulating material in the dielectric breaks down and burns out. The capacitor then is shorted, and the flow of direct current through it can cause damage to other parts of the equipment. Capacitors have a voltage rating that you should never exceed.

The working voltage of a capacitor is the maximum d-c. voltage that can be applied steadily without harm to the capacitor. The working voltage depends on (1) the type of material used as the dielectric and (2) the thickness of the dielectric.

Capacitors in Series

When two or more capacitors are connected in series, the total capacitance is the same as that of a single capacitor with a thicker dielectric. The thicker the dielectric, the smaller the capacitance. Therefore, the total capacitance of capacitors in series is less than the capacity of the smallest capacitor.

The total capacitance of capacitors in series is found by the equation:

$$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \cdots$$

As the thickness of the dielectric effectively increases when capacitors are connected in series, the working voltage of the combination is increased. Theoretically, the working voltage should equal the sum of the voltage ratings for each capacitor. However, an applied d-c. voltage divides in direct proportion to the d-c. leakage resistance of the dielectrics, and, as leakage resistance of dielectric materials varies with many factors, the working voltage of capacitors in series is not as large as the sum of the individual ratings.

Capacitors in Parallel

When you connect capacitors in parallel, you effectively increase the surface area of the plates. As increasing the area of the plates increases the capacitance of a capacitor, the total capacitance of capacitors in parallel is equal to the sum of the individual capacitance. This may be stated as:

$$C_T = C_1 + C_2 + C_3 + \ldots$$

Note that capacitors in series are added like resistors in parallel, and that capacitors in parallel are added like resistors in series.

The break-down voltage of capacitors in parallel is no greater than that of the weakest capacitor in the group.

Capacitive Reactance

Reactance is the opposition of a device to flow of alternating current. The opposition of a capacitor to flow of alternating current is called *capacitive reactance*. It is not called resistance because it differs from the resistance of a resistor in two basic ways—(1) it depends on frequency and (2) the phase relations are different.

Ohm's Law for Capacity

Ohm's law can be applied to capacitors as well as resistors. Ohm's law for capacitors states that capacitive

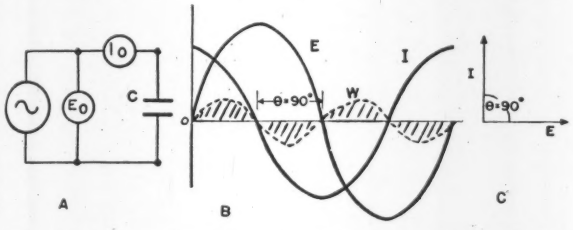

Fig. 2-9. Action of a capacitor. A, experimental circuit for measuring current and voltage; B, curves of current (I), voltage (E), and power (W); C, phase of current and voltage.

reactance, X_C, equals the potential across the capacitor (volts) divided by the current through the capacitor (amperes). That is:

$$X_C = E/I,\ E = IX_C, \text{ or } I = E/X_C.$$

The unit of reactance is the same as for resistance—the *ohm*.

Frequency

Fig. 2-9,A shows a capacitor connected to an a-c. generator of variable frequency but fixed voltage. I_0 and E_0 are instruments for measuring the current and voltage. Note that the voltage is measured across the capacitor, and that the current is the current through the capacitor. As the frequency of the generator is raised, the a-c. current in the circuit increases, even though the voltage applied remains constant. This proves that the opposition to current flow offered by the capacitor varies inversely with the frequency of the current. As frequency goes up, the opposition goes down. This is shown by the formula for capacitive reactance:

$$X_C = 1/(2\pi FC),$$

where F is the frequency of the current (cps.), C is the capacitance of the capacitor (farads), and X_C is the reactance (ohms).

Note that X_C is inversely proportional to the frequency and also to the capacitance—that is, the reactance decreases for higher frequency and larger capacitance.

Phase

Fig. 2-9,B shows the current (I) through the capacitor and the voltage (E) across the capacitor. Note that the current is ¼ cycle, or 90 degrees, *ahead* of the voltage. This is a fundamental difference between a capacitor and a resistor. The phase relations are shown vectorially in Fig. 2-9,C.

It is important to remember that the voltage across a capacitor (from plate to plate) is 90 degrees out of phase

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with the current through the capacitor. This means that in any circuit with capacitance, the voltage and current cannot be exactly in phase. However, as no circuit consists entirely of pure capacitance, the current and voltage are not exactly 90 degrees out of phase. The phase difference between the current and voltage in practical circuits depends on the relative amounts of reactance and resistance.

Power

Power is the product of current and voltage. When the current and voltage are alternating, the power at any instant is the product of the instantaneous values of the current and voltage. Fig. 2-9,B shows a power curve (W) obtained by multiplying the instantaneous values of the current (e) and voltage (i) in a capacitor. Note that the power is positive for ¼ cycle and negative for the next ¼ cycle. The periods of positive power represent the time when the electric field is building up, which is the time when the capacitor charges. The periods of negative power represent the time when the capacitor is discharging and returning its energy to the circuit. In a purely capacitive circuit, the capacitor returns as much energy to the circuit on alternate quarter cycles as it consumes on the other quarter cycles, and the average power consumed and dissipated is zero.

Uses of Capacitors

Storage

Capacitors are used in two basic ways. The first way is as a *storage* device. When you charge a capacitor, one plate accumulates an excess, and the other plate a deficiency, of electrons because electrons cannot flow through the dielectric. By utilizing the storage ability of a capacitor, you can (1) charge a capacitor from a battery or any source of d-c. potential, (2) hold the charge for an interval of time, and (3) regulate the charging and discharging time. This application is useful for shaping signals in instruments such as counters. The storage characteristic is used also in *integration*. When used as a storage device, the capacitor is charged, and a potential exists *across* the capacitor—that is, the plates are at different potentials.

Coupling

The second way in which a capacitor is used is as a coupling device. When used as a coupling device, a capacitor passes alternating current and blocks direct current.

A coupling capacitor in a properly designed circuit passes alternating current with practically no opposition. Because of the small opposition, the voltage developed *across* the coupling capacitor—IX_c—is negligible, and almost all the signal voltage appears across the load. The important things to remember when a capacitor is used as an a-c. coupler are (1) the a-c. signal passes through the capacitor at almost the speed of light and with insignificant loss in amplitude, (2) the two plates of the capacitor follow the signal almost instantaneously, (3) the potential drop *across* the capacitor is insignificant, and (4) the capacitor does not charge or discharge appreciably during the a-c. cycle. Note that a coupling capacitor can pass an a-c. signal whose peak-to-peak amplitude exceeds the working voltage. This is because the IX_c drop across the capacitor remains small.

Fig. 2-10 shows a coupling network between two circuits. The signal developed across the resistor passes through the capacitor with insignificant change in phase or amplitude. The capacitor acts like a solid conductor to the a-c. signal. However, the coupling capacitor blocks the d-c. potential of the first circuit from the second circuit.

Capacitors are used also as frequency-sensitive couplers

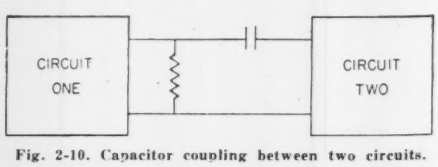

Fig. 2-10. Capacitor coupling between two circuits.

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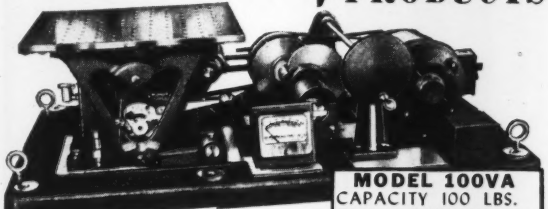

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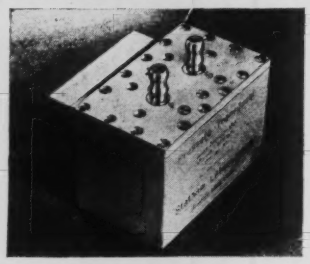

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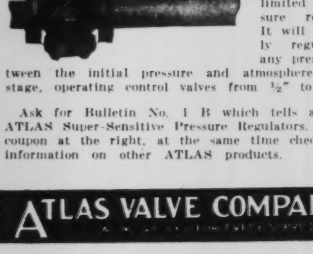

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in differentiating instruments. As the reactance of a capacitator decreases for increasing frequency, a capacitor can be used to pass high-frequency a-c. signals and block low-frequency a-c. signals. This is the basis for *differentiation.*

An important use of capacitors is as an element in a resonant circuit. They are used in conjunction with inductors for this application.

Types

As shown in Fig. 2-11, various types of capacitors are used in electronic circuits. The five most common types are the variable, paper, mica, ceramic, and electrolytic capacitors.

Variable capacitors are used in circuits where the capacitance must be continuously variable, such as tuning controls in radio receivers and signal generators. Most variable capacitors are of the air-dielectric type. A simple variable capacitor consists of two sets of metal plates, brass or aluminum, insulated from each other and arranged so that one set of plates can be moved with respect to the other. The stationary plates form the *stator*, and the movable

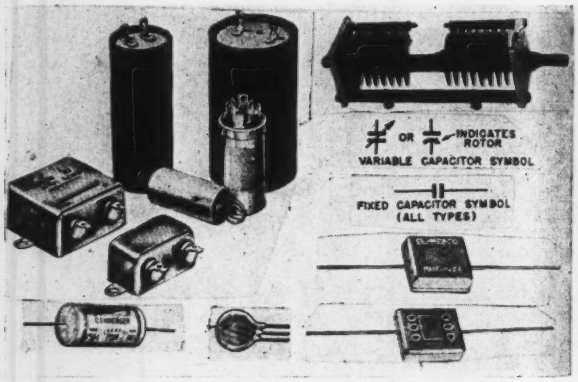

Fig. 2-11. Types of capacitors. Upper left, electrolytics; upper right, variable; lower left, paper; lower center, dual ceramic-dielectric; lower right, mica.

plates form the *rotor*. When the two sets of plates are fully meshed, the entire surface areas of the two sets of plates are facing one another and maximum capacitance exists. When the rotor is completely unmeshed with the stator, minimum capacitance exists because the area of the plates facing each other is a minimum. Variable capacitors range in size from about 1 micromicrofarad to 1,000 micromicrofarads.

Small variable capacitors are called *trimmers* and *padders*. They are used widely for fine tuning in radio sets and instruments. Air and mica are used as the dielectric.

Paper capacitors consist of two or more long strips of tinfoil separated by thin waxed paper and rolled together into a compact form. Paper capacitors are made in fixed capacity from about 0.0001 microfarad to about 2 microfarads. They are used mainly for audio and r-f. bypassing and for coupling between stages. The d-c. working voltage that they can withstand is marked on the label of the capacitor.

Mica capacitors, which are used mainly as bypass and coupling capacitors in r-f. circuits, are made in sizes from about 10 to 10,000 micromicrofarads. They consist of two or more strips of metal foil separated by thin sheets of mica. The complete unit is pressed into a compact form and encased in insulating material.

Ceramic capacitors, like mica capacitors, are used for bypass and coupling, and are made in sizes from about 10 to 10,000 micromicrofarads. They are characterized by small size.

Electrolytic capacitors depend on a chemical action to form a dielectric of a very thin film of oxide. One plate of the capacitor is aluminum, and the other plate, which is the electrolyte, is a borax solution. In operation, a thin coat of oxide forms on the sheet of aluminum and serves as the dielectric. As the film of dielectric is extremely thin,

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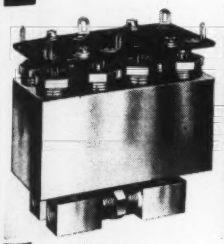

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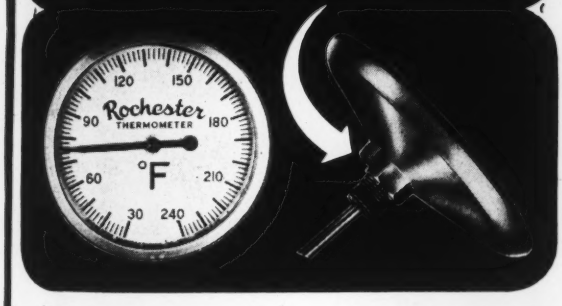

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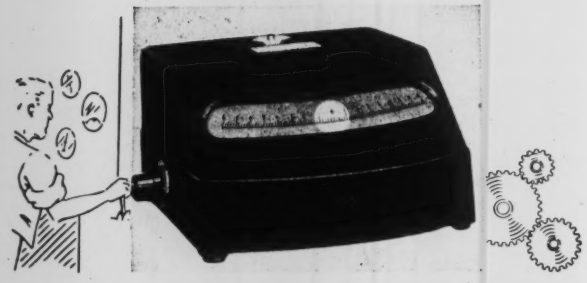

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electrolytic capacitors of small dimensions can be made with capacitance as high as 1,000 microfarads.

In operation, the electrolytic capacitor passes a "leakage" d-c. current, which is required by the chemical action in forming the dielectric. This current is about 0.5 milliampere per microfarad of capacity at the rated voltage. The leakage increases after a period of disuse because the electrolytic film deteriorates in storage.

An electrolytic capacitor is *polarized*—that is, it has a positive and a negative terminal, both of which must be connected properly in a circuit. Thus, an electrolytic capacitor can be used only in circuits with a steady or a pulsating direct current applied to the terminals. A reverse current destroys the oxide film and the capacitance of electrolytic capacitors.

The aluminum plate need not be a straight sheet but may be rolled, as in a paper capacitor, to give greater effective plate area. The capacitance of an electrolytic capacitor usually is high because of the thin dielectric. Electrolytic capacitors range in size from about 4 microfarads to about 1,000 microfarads. Because of their high capacitance, they are used commonly in filter systems of power supplies.

The type of electrolytic capacitor described is known as a wet electrolytic. A variation of this type is the so-called "dry" electrolytic. Although this capacitor is not dry, it is said to be dry because the electrolyte is not liquid; instead, a gauze that is saturated with a solution is used. The dry electrolytic capacitor is preferable to the wet type because it is sealed at both ends and the solution cannot evaporate.

Electrolytic capacitors are used extensively in power supplies and low-frequency amplifiers where large values of capacitance are required. Although metallized paper capacitors are much smaller than conventional paper capacitors, they are still too bulky and expensive for use in low-frequency circuits. Electrolytic capacitors are not as good as paper capacitors for three reasons—(1) they cannot operate at high temperatures, (2) their shelf life is shorter, and (3) they absorb charges. The absorbed charge is a source of spurious potential in low-level circuits.

Color Codes for Resistors and Capacitors

Fixed resistors and some fixed capacitors usually are labeled with a color code to indicate value and tolerance. The color code for resistors and capacitors is used universally and should be remembered by all instrument men.

The Radio Manufacturer's Association (RMA) has standard color codes for power transformers, audio transformers, i-f. transformers, battery power cables, and dynamic-speaker connections in addition to the color code for resistors and capacitors. The RMA standards are used by most manufacturers.

The RMA standard color codes for resistors and capacitors are given in Table I.

Color Significance

The value of a resistor or capacitor is found from the colors, which usually indicate two significant figures and a decimal multiplier. An easy fact to remember is that the

TABLE I—COLOR CODE

Color	*Significant figure*	*Decimal multiplier*	*Percentage of tolerance* RMA 1938	*Voltage rating* RMA 1938*
Black	0	1	—	—
Brown	1	10	1	100
Red	2	100	2	200
Orange	3	1,000	3	300
Yellow	4	10,000	4	400
Green	5	100,000	5	500
Blue	6	1,000,000	6	600
Violet	7	10,000,000	7	700
Gray	8	100,000,000	8	800
White	9	1,000,000,000	9	900
Gold	—	0.1	± 5	1,000
Silver	—	0.01	±10	2,000
No color	—	—	±20	500

* Applies to capacitors only

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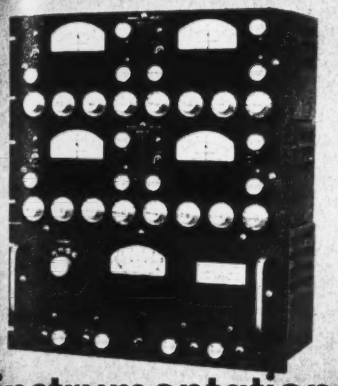

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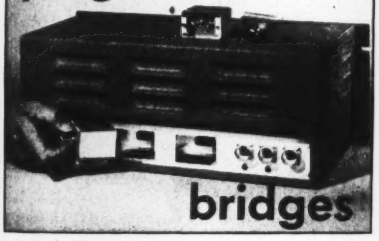

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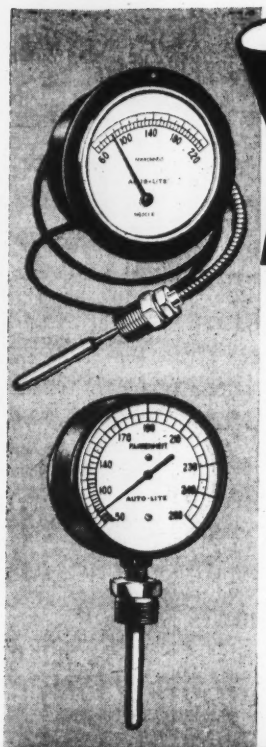

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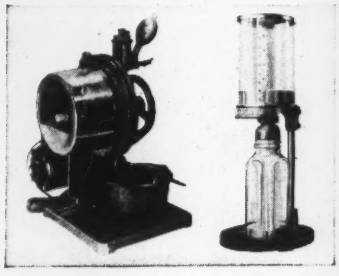

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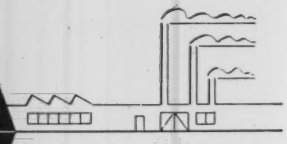

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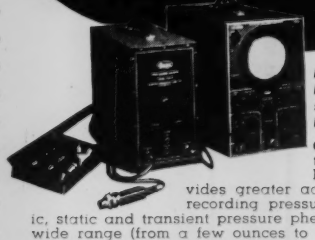

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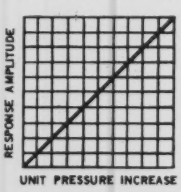

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number of zeroes added to the significant figures by the decimal multiplier is equal to the numerical value of the color. The numerical value of each color from 0 to 9 should be committed to memory.

Aids to memory have been used successfully in memorizing the color code. One such aid is based on the name *Roy G. Biv*, as shown in Table II. The name contains the first letters of six colors of the code in proper sequence: Red, orange, yellow, green, blue-indigo, and violet. Note that these are the colors of the spectrum in order of increasing frequency. The four remaining colors can be recalled with the aid of another device. Black is the absence of light, that is, no color. It is a logical choice for zero. Brown is almost black and is number one. White is a color that contains all other colors and is a logical choice for the largest number, nine. Grey is almost white and is eight. The use of these aids to memory quickly calls to mind the color code.

Resistors, Fixed, Composition

The color coding of axial- and radial-lead fixed composition resistors is shown in Fig. 2-12. The exterior body

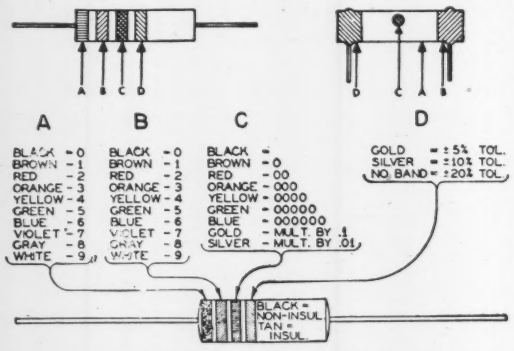

Fig. 2-12. Color coding of axial- and radial-lead fixed composition resistors.

color of insulated axial-lead composition resistors is usually tan, but other colors except black are permitted. The black body color is used on non-insulated axial-lead composition resistors. Radial-lead composition resistors have a body color representing the first significant figure of the resistance value.

Resistors manufactured before the war were multiples of 5 and 10. Recent manufacturing and sales policy has resulted in a new set of values called preferred values of resistance, which are not multiples of 5 and 10. A partial list (one decade) of the new preferred resistance values is given in Table III.

Capacitors, Fixed, Mica-dielectric

The RMA Standard uses either a simple three-dot color code indicating only the capacitance, or a six-dot color code showing three significant figures (instead of the usual two), decimal multiplier, tolerance, and voltage rating. The RMA three-dot and six-dot systems are shown in

TABLE II—MEMORY AIDS FOR THE COLOR CODE

No.	*Color*	*Memory aids*
0	Black	No color.
1	Brown	Almost black.
2	Red	R
3	Orange	O
4	Yellow	Y
5	Green	G
6	Blue-indigo	Bi
7	Violet	V
8	Grey	Almost white.
9	White	All colors.

TABLE III—PREFERRED VALUES OF RESISTANCE

±20%	10				15				22				33				47				68				100
±10%	10		12		15		18		22		27		33		39		47		56		68		82		100
± 5%	10	11	12	13	15	16	18	20	22	24	27	30	33	36	39	43	47	51	56	62	68	75	82	91	100

This represents the actual size of the housing which totally encloses the Ulanet

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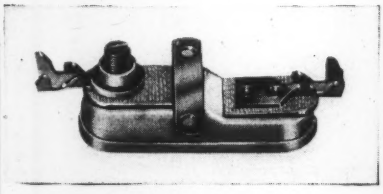

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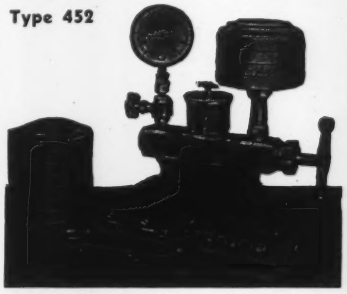

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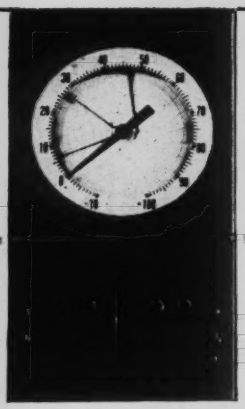

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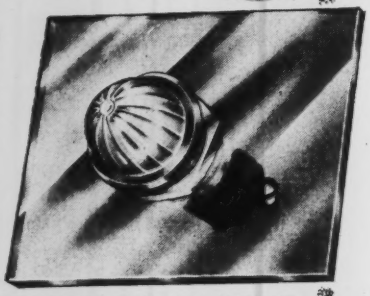

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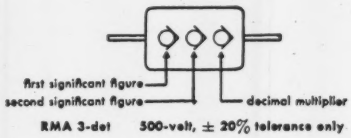
Fig. 2-13. Capacitance values are expressed in micromicrofarads up to 10,000 micromicrofarads.

Capacitors, Fixed, Ceramic-dielectric

Tubular ceramic-dielectric capacitors are used for temperature compensation of tuned circuits and other applications. If the capacitance, tolerance, and temperature coefficient are not printed on the capacitor body, the color



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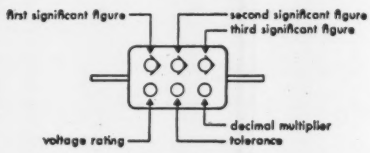
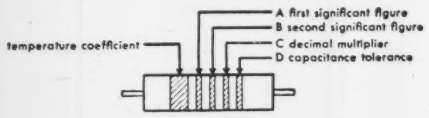


RMA 6-dot

Fig. 2-13. RMA 3-dot and 6-dot color codes for mica capacitors.



color	significant figure	multiplier	capacitance tolerance in °C: ε > 10 μμf	capacitance tolerance in μμf: ε ≤ 10 μμf	temperature coefficient parts/million/°C
black	0	1	±20	2.0	0
brown	1	10	±1		−30
red	2	100	±2		−80
orange	3	1,000			−150
yellow	4	—			−220
green	5	—	±5	0.5	−330
blue	6	—			−470
violet	7	—			−750
gray	8	0.01		0.25	+30
white	9	0.1	±10	1.0	

Fig. 2-14. Color code for fixed ceramic capacitors.

code in Fig. 2-14 is used. The change in capacitance per unit capacitance per degree centigrade is the temperature coefficient, usually stated in parts per million per degree centigrade (p.p.m./°C.).

TEST ITEMS FOR—II. CIRCUIT ELEMENTS

Part 1.—Resistors and Capacitors

2-1. The most common type of a-c. wave is a
- (a) square wave
- (b) sine wave
- (c) saw-tooth wave
- (d) series of spike-shaped impulses

2-2. The frequency of a sine wave is the
- (a) period of one cycle
- (b) period of two cycles
- (c) number of half cycles per second
- (d) number of complete cycles per second

2-3. A sine wave is represented by a vector which
- (a) rotates counterclockwise
- (b) rotates clockwise
- (c) is horizontal
- (d) is vertical

2-4. A sine wave changes amplitude most rapidly when it
- (a) reaches maximum positive amplitude
- (b) reaches maximum negative amplitude
- (c) passes through zero amplitude
- (d) passes through the rms. amplitude

2-5. Power resistors are usually
- (a) wire wound
- (b) composition
- (c) metal film
- (d) woven wire

2-6. Ohm's law for resistors is
- (a) R = E/I
- (b) R = EI
- (c) R = I/E
- (d) R = 1/EI

2-7. The opposition to current flow offered by a resistor

ANSWERS TO QUIZ I

1-1.	(b)			1-14.	(d)			1-27.	(a)		
1-2.	(d)	1-8.	(d)	1-15.	(d)	1-21.	(b)	1-28.	(d)		
1-3.	(a)	1-9.	(c)	1-16.	(b)	1-22.	(c)	1-29.	(d)		
1-4.	(b)	1-10.	(c)	1-17.	(b)	1-23.	(c)	1-30.	(b)		
1-5.	(c)	1-11.	(d)	1-18.	(d)	1.24.	(d)	1-31.	(d)		
1-6.	(c)	1-12.	(a)	1-19.	(a)	1-25.	(d)	1-32.	(c)		
1-7.	(c)	1-13.	(a)	1-20.	(d)	1-26.	(a)	1-33.	(b)		

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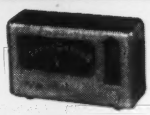

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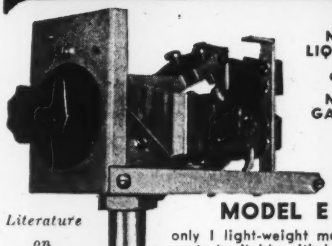

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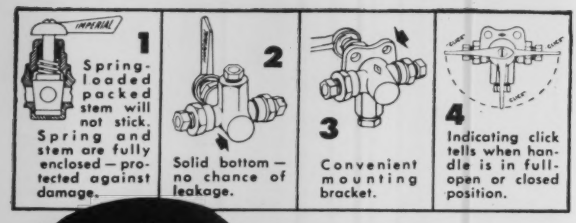
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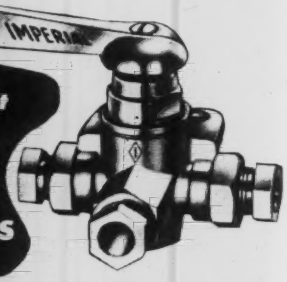

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differs from the opposition offered by a capacitor or an inductor in that the former
- (a) increases with the frequency of the current
- (b) decreases with the frequency of the current
- (c) is independent of the frequency of the current
- (d) has a phase which depends on the frequency of the current

2-8. The formula for power dissipated by a resistor is
- (a) $W = EI$
- (b) $W = I^2R$
- (c) $W = E^2/R$
- (d) all the above

2-9. The resistance of two 10-ohm resistors and one 5-ohm resistor connected in parallel is
- (a) 0.4 ohm
- (b) 1 ohm
- (c) 2.5 ohms
- (d) 25 ohms

2-10. If a current of 10 milliamperes (0.010 ampere) flows through a resistor of 10,000 ohms, the voltage developed across the resistor is
- (a) 1 volt
- (b) 10 volts
- (c) 100 volts
- (d) 1000 volts

2-11. The chief disadvantage of carbon composition resistors is
- (a) poor high-frequency characteristic
- (b) poor stability
- (c) high cost
- (d) large size

2-12. A capacitor passes
- (a) a.c. only
- (b) d.c. only
- (c) both a.c. and d.c.
- (d) neither a.c. nor d.c.

2-13. The capacitance of a capacitor depends on
- (a) the area of the plates only
- (b) the thickness of the dielectric only
- (c) the nature of the dielectric only
- (d) all the above

2-14. The total capacitance of four 0.01-μf. capacitors in series is
- (a) 0.0004 uf.
- (b) 0.0025 uf.
- (c) 0.025 uf.
- (d) 0.04 uf.

2-15. Reactance differs from resistance in that
- (a) it varies with frequency
- (b) the current and voltage are in phase
- (c) Ohm's law can not be used
- (d) all the above

2-16. The reactance of a capacitor depends on the
- (a) working voltage of the capacitor
- (b) phase of the signal
- (c) voltage of the signal
- (d) frequency of the signal

2-17. A microfarad is a unit of
- (a) capacitance
- (b) reactance
- (c) resistance to current flow
- (d) all the above

2-18. Reactance is a
- (a) unit of capacitance
- (b) unit of resistance
- (c) resistance to flow of d.c.
- (d) resistance to flow of a.c.

2-19. The reactance of a 0.1-uf. capacitor to a 60-cps. alternating current is about
- (a) 0.0265 ohm
- (b) 26.5 ohms
- (c) 26,500 ohms
- (d) 265,000 ohms

2-20. The reactance of a 0.1-uf. capacitor to a 600-kc. (600,000-cps.) alternating current is about
- (a) 0.0265 ohm
- (b) 2.65 ohms
- (c) 265 ohms
- (d) 26,500 ohms

2-21. A capacitor designed to couple an a-c. signal from one circuit to another should have a
- (a) high reactance to the signal
- (b) low reactance to the signal
- (c) working voltage greater than the signal voltage
- (d) working voltage lower than the signal voltage

2-22. Capacitors are used for
- (a) storing charge
- (b) coupling a-c. signals
- (c) differentiation
- (d) all the above

2-23. When an a-c. voltage is applied across a capacitor, the current through the capacitor
- (a) lags the voltage by 90 degrees
- (b) leads the voltage by 90 degrees
- (c) is in phase with the voltage
- (d) leads the voltage by ½ cycle

2-24. An advantage of electrolytic capacitors is
- (a) high capacity
- (b) polarized operation
- (c) chemical action
- (d) all the above

2-25. A disadvantage of electrolytic capacitors is
- (a) low shelf life
- (b) absorbed charge
- (c) low required operating temperature
- (d) all the above

2-26. A resistor has standard color-code bands of (a) yellow, (b) violet, and (c) yellow. The resistance of the resistor is
- (a) 33,000 ohms
- (b) 37,000 ohms
- (c) 470,000 ohms
- (d) 4,800,000 ohms

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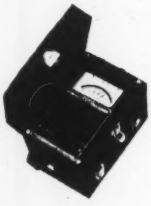

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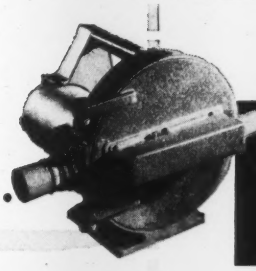

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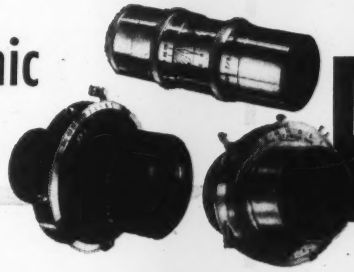

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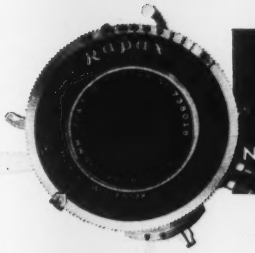

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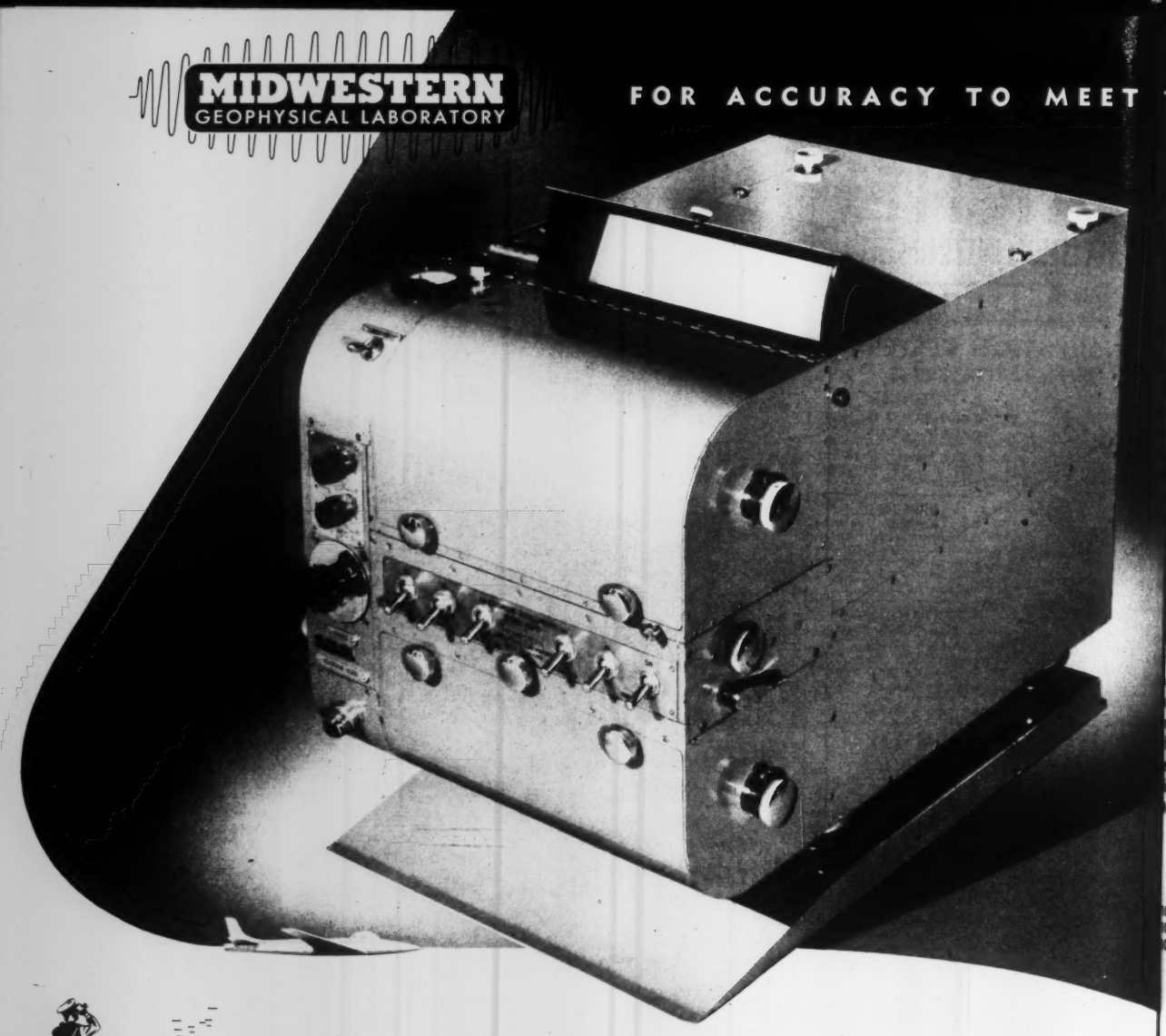

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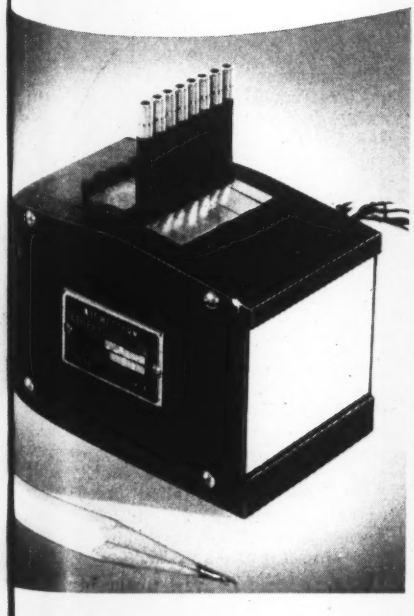
SS Type	Nominal Undamped Natural Frequency	D.C. Sensitivity 12" Optical Arm (Undamped) Ma/In.	Nominal Galavnometer Resistance Ohms
106-100	100	0.006	35
106-150	150	0.013	35
106-200	200	0.022	35



Thermocouple Symposium

Continued from page 877

special melt ingredients, but that RP-1080 wire could be obtained from standard ingredients which are readily available. However, when asked if the RP-1080 wire required American or Norway iron, Mr. Robert Grant (Brown Instrument Div. of Minneapolis-Honeywell) stated that wire in accordance with RP-1080 required a very pure iron and that his Company manufactured only wire in accordance with the L&N 1913 calibration. Mr. Grant further stated that he believed that approximately 90 to 95 percent of all I-C thermoucouple wire used today was calibrated in accordance with L&N 1913 rather than RP-1080.

When asked what effect, if any, a change from RP-1080 to the A1 calibration would have on lab test equipment and lab operations such as those of Douglas Aircraft Corp., Mr. Dennis stated that the change from RP-1080 would affect their test lab considerably. Although commercial instruments use mostly L&N, aircraft instruments use RP-1080 almost exclusively. At a temperature of 1800 F., there is approximately a five-degree difference between these two calibrations, and this would be too great an error to accept. Mr. McNeely stated that converting instruments from the RP-1080 to the A1 calibration would entail trouble and would require new instrument scales and new cold-junction temperature compensation. He also stated that proper identification of the type of wire being used could pose a serious problem if more than one type of wire were used within the same testing organization.

Mr. Grant stated that most process industries operate between 100 and 300 F. with accuracies of about one percent, and that these industries would not be affected by changing from L&N 1913 to the A1 calibration; however, some process operations, such as the hardening of aluminum, would run into trouble without recalibrating. If recalibrating were necessary, plates for new charts cost approximately $115.00 each and require approximately 12 to 15 weeks for delivery.

Based on the discussion up to this point, Mr. Warner called for a showing of hands as to preferences for wire calibration, with the following results:

(1) Three persons expressed a desire to eventually change to the proposed A1 calibration, but for the present to adopt an interim standard which would represent an average between RP-1080 and the proposed A1 calibration.

(2) Five persons present expressed a desire to retain two calibrations, namely RP-1080 for those who are currently using this type of wire, and the A1 calibration for those who are using the L&N 1913 type of wire.

(3) *Fourteen persons expressed a desire to adopt the A1 calibration as a universal iron-constantan thermocouple standard at the earliest practical date and to abandon all other calibrations.*

At this point, Mr. Fine commented

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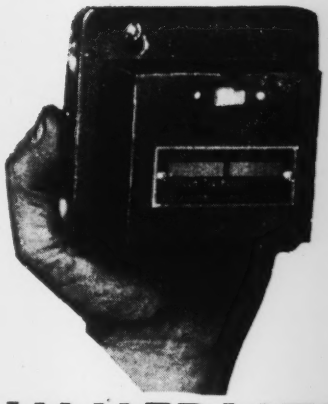

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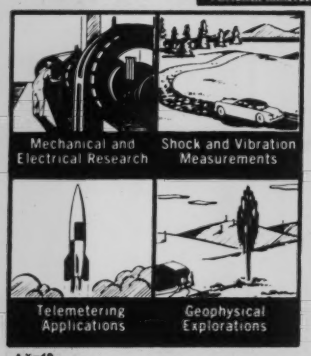

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that he believed it to be a bad time to change standards, in that the delivery situation is poor at this time and emergency conditions make it difficult for the Services to make a change.

Summarizing, Mr. Warner stated that it appeared that the majority of users would be in favor of converting at the earliest practical date to the proposed A1 standard if such a conversion would be approved by the Military Services; however, if the Military Services should not go along with such a proposal, the alternative choice would be to retain, for the present time, two standards, namely the RP-1080 thermocouple standard for the Military users, and the A1 thermocouple standard for all other users. The ultimate goal would be universal acceptance of the A1 calibration curve.

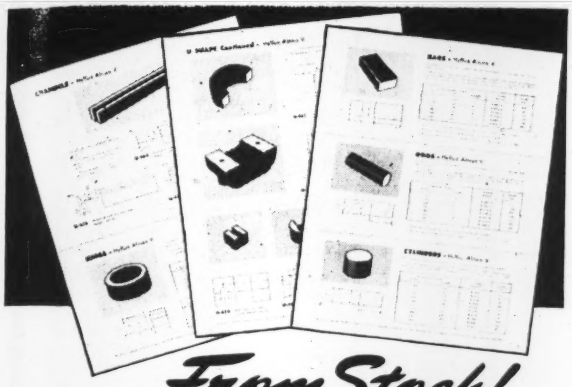
Use of Platinum as Reference Metal

The possibility of referencing the calibration of the various thermocouple metals to platinum rather than to each other was also discussed, the purpose being to permit precise pairing and rematching of wire by all ultimate users. However, the consensus was that, although such a referencing to platinum would be desirable from the point of view of the thermocouple wire users, nevertheless it would be impractical from the point of view of the manufacturers of this wire, because much of the wire presently used for thermocouples and meeting present specifications would not come close enough when referenced to platinum and would therefore not be usable. As a result, thermocouple wire, already in short supply, would become extremely critical insofar as supply is concerned, and it would also become considerably more costly. This appears to be too great a price to pay for the added convenience of being able to indiscriminately match up iron and constantan wires from various batches and yet still obtain the desired calibration.

Military Thermocouple Specifications

The proposed revisions to Military Specification MIL-W-5845 for iron-constantan thermocouple wire and MIL-W-5846 for chromel-alumel thermocouple wire were discussed. It was recommended that the specifications be ammended to provide that each spool of thermocouple wire be plainly marked as to lot number so that, in the case of single wires, they could be properly paired with other wires from the same lot number. It was also stated that the use of a color coding of light blue with green tracers was poor in that the blue eventually turns green with use. It was further suggested that the ISA's proposed wire color code be compared with the proposed Military color code and that the two proposed color code standards be made fully compatible before finalization. It was further recommended that the specification be amplified to include wire in gage sizes 22, 28, and 30.

Some discussion was held regarding



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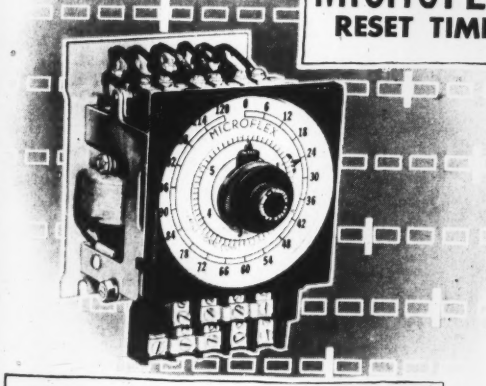

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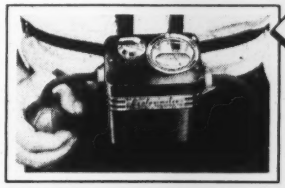

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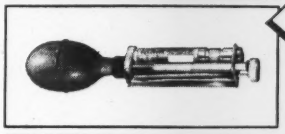

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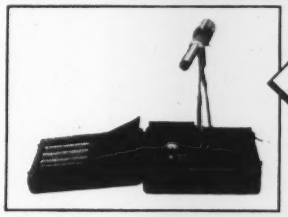

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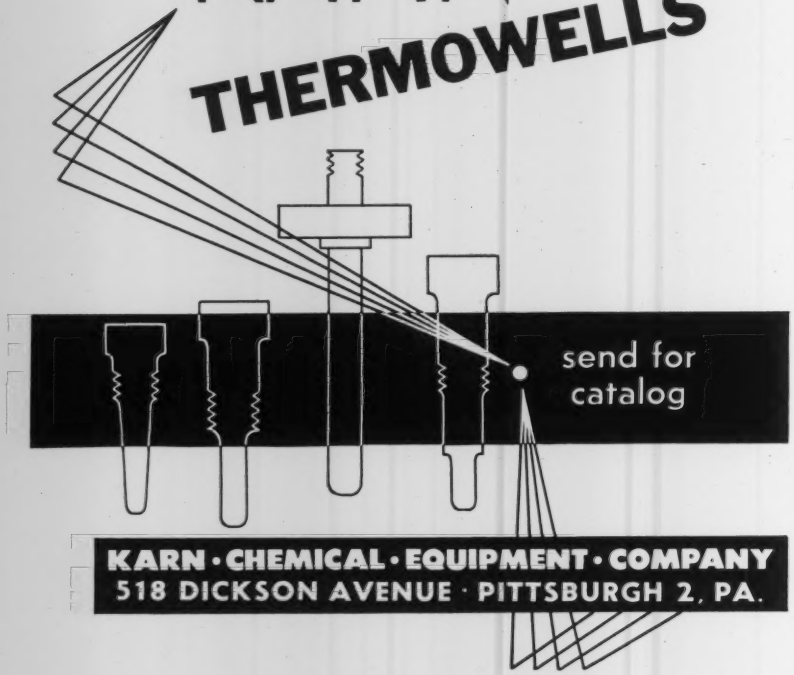

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the desirability of tinning iron thermocouple wire, and it was pointed out that temperature errors introduced by tinning the wire seriously affected the over-all accuracy of the measuring system, and it was the general feeling that tinning should be avoided except in the case of extension lead-wire.

APPENDIX

List of Persons Attending IAeS-ASME Thermocouple Symposium, June 19, 1951, Los Angeles, Calif.

Chairman

D. K. Warner, Member, Joint Aviation instruments Committee, IAeS and ASME.

Discussion Panel

H. D. Alexander, Field Engineer, Lewis Engineering Corp.

L. S. Collins, Field Engineer, Pacific Scientific Co.

B. M. Craig, Consulting Engr, Pasadena, Calif., Member Joint Committee.

P. A. Dennis, Chief of Engineering Lab, Douglas Aircraft Corp., El Segundo Division.

R. L. Fine, Project Engineer, Air Development Force, Wright-Patterson Air Force Base.

T. L. McNeely, Flight Engineer, North American Aviation, Inc.

M. D. Pugh, *Instruments* Magazine and Instrument Society of America.

Others Attending

H. G. Blaugh, Insp. Dept., AiResearch Mfg. Co.

F. E. Bryan, Research Engineer, Douglas Aircraft, Santa Monica.

R. J. Fraser, Sales Repr., Clary Multiplier Corp., Aviation Hardware Div.

R. B. Grant, Industrial Manager, Minneapolis-Honeywell Regulator Co.

L. H. Groeper, Ass't Supervisor, North American Aviation, Inc.

A. Z. Guarero, Insp. Dept., AiResearch Mfg. Co.

J. W. Hoffman, Research Engineer, North American Aviation, Inc.

N. E. Johnson, Supervisor Data Reduction, North American Aviation, Inc.

D. Karl, Flight Test Engineer, North American Aviation, Inc.

W. J. Kirby, Sales Engineer, Minneapolis-Honeywell Regulator Co.

R. D. Lumley, Research Engineer, North American Aviation, Inc.

B. Minassian, Aerodynamics Engineer, Northrop Aircraft, Inc.

R. E. Owens, Elec. Insp., AiResearch Mfg. Co.

A. C. Plautz, Research Engineer, Douglas Aircraft, Santa Monica.

E. W. Robischon, Westn. Reg. Mgr., Institute of the Aeronautical Sciences.

F. E. Romie, Assoc. Engineer, North American Aviation, Inc.

D. M. Swanton, Sales Engineer, Pacific Scientific Co.

J. B. Werner, Designer, North American Aviation, Inc.

F. W. Worden, Insp., AiResearch Mfg. Co.

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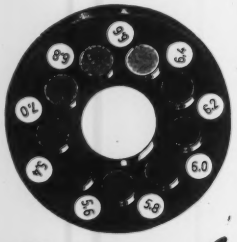

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THE SECRETARY'S PAGE

BY the time you read this page, you will have received your invitation to the Sixth National Instrument Conference and exhibit and the Tentative Program. We hope your hotel reservation has been made and your transportation arranged. A recent report from the Houston hotels indicates that over 90 percent of the rooms set aside for ISA members are reserved.

"Bill" Wildhack, V.P. in Charge of the Technical Division, reports that the Technical Program will be much expanded over other meetings. It will have much information of value to every member. The popular Instrument Maintenance Clinic will be continued.

Here is a preview of the Technical Program. The titles of most of the papers to be presented are listed below. This list is by no means complete. The Tentative Program contains a more complete listing and shows the time and place of presentation. If you have not received a copy, write the National Office.

ISA Program

Instrumentation for Production Processes

Monday morning session

"Instrumentation of Tire Curing Presses," by R. N. Wilson (Kelly-Springfield Tire Co., . . .).

"Operation of a Semi-Continuous Process Using the Kine-Graphic Control Board," by J. Johnson Jr. and J. E. Read (E. I. DuPont, Wilmington, Del.).

"Turbine Governors as Related to Pneumatic Controls," by J. E. Pellettere (Gulf Oil Co., . . .).

Tuesday morning session

"Pneumatic Weighing," by D. Glover (Fluid Controls Co., . . .).

"An AC Induction Flow Meter," by W. G. James (Oak Ridge National Lab., Oak Ridge, Tenn.).

"Simplified Orifice Bore Calculations," by W. I. Caldwell (Taylor Instrument Companies, Rochester, N. Y.).

Wednesday morning session

"Completely Automatic Control System for the Distillation Process," by I. Lefkowitz (J. E. Seagram & Son, Inc., . . .).

"Improved Flow Control with Long Lines," by W. E. Vannah (Foxboro Co., Foxboro, Mass).

"Microsen Electric & Pneumatic Transmission of Temperature and Pressure," by C. G. Roper (Manning, Maxwell & Moore, Inc., Stratford, Conn.).

Instrumentation for Transportation

Thursday morning session

"The Electrical Speedometer Application to Transportation," by J. J. Groncki (Instrument Engineering Div., G. E. Co., . . .).

"A Review of the Electric Displacement Gauges Used in Railroad Car Testing," by W. Kneen, (Pullman Standard Car Mfg. Co., Hammond, Ind.).

Analysis Instrumentation

Monday morning session

"Practical Application of Electron Diffraction," by S. P. Newbury & E. I. Allessandrini (General Electric Co., . . .).

"Continuous Recording Electrometric Titrometer," by K E. Hallikainen and D. J. Pompeo (Shell Dev. Co., . . .).

"An Improved Luft-Type Infra-Red Gas and Liquid Analyzer," by J. L. Waters (J. L. Waters, Inc., Framington, Mass.), and N. W. Hartz (Mine Safety Appliances Co., Pittsburgh, Pa.).

Tuesday morning session

Panel Discussion of Problems of Analysis Instrumentation. 5 Panel Members.

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Section Secretaries, Meeting Data and Programs

AKRON
Fred Appel, 932 Columbia Ct., Barberton, Ohio. Tel: SH 3440
Fourth Tuesday, 7:30 P. M., Akron Y.W.C.A.

ALBUQUERQUE
W. E. Bostwick, 2615 Sandia Dr., Bel Air, Albuquerque, N. Mex.
First Monday, Meeting at 8:00 P.M., Science Lecture Hall, Univ. of N. M.

ARUBA
E. H. Pfeffer, P.O. Box 291, c/o Lago Oil & Transport Co., Ltd., Aruba, N.W.I.
First Tuesday, 7:15 P. M., Engr's Club.

ATLANTA
D. M. McRae, 150 Nassau St., Atlanta, Ga.
Fourth Monday, Meeting at 7:45 P.M., Ga. Institute of Technology.

BALTIMORE
G. B. Greer, 631 East 36th St., Baltimore 18, Md.
Second Friday, Meeting at 8:00 P.M., Engr's. Club of Baltimore.

BATON ROUGE
John Q. Bass, 1517 Longwood Dr., Baton Rouge, La. Tel: 3-0283
Meeting monthly, L.S.U. Physics Bldg.

BOSTON
Stephen E. Lord, 60 Braintree Ave., Quincy 69, Mass. Tel: MA 9-1066
Last Wednesday, Dinner at 6:30 P. M., Meeting at 7:00 P.M., 99 Club, 99 State St.

CALIFORNIA
D. C. Duncan, Helipot Corp., 916 Meridian Ave., S. Pasadena, Calif. Tel: SY 4-8439
Second Wednesday, Dinner at 6:30 P. M. Meeting at 8:00 P.M., Carolina Dines.

CENTRAL ILLINOIS
H. R. Getz, 723 Laura Ave., Peoria 5, Ill.
First Wednesday, Dinner at 6:30 P.M., Meeting at 7:30 P.M.

CENTRAL INDIANA
Richard F. Rieman, 3550 Euclid St., Indianapolis, Ind. Tel. CH 7462
First Tuesday, Meeting at 7:30 P. M.

CENTRAL NEW YORK
Karl W. Robertson, Minneapolis-Honeywell Reg. Co., 121 Onondaga St., Syracuse.

CHARLESTON
Fred Gilmer, 418 Beech Ave., Charleston, W. Va.
First Monday, Dinner at 6:15 P.M., Meeting at 8:00 P.M., Kanawha Hotel

CHICAGO
Floyd E. Ertsman, Rm. 1410 Fisher Bldg., 343 S. Dearborn St., Chicago 4, Ill. Tel: WE 9-0686
First Monday, Dinner at 6:30 P. M., Meeting at 8:00 P. M., Shoreland Hotel.

CHINA LAKE
A. H. Staud, 1004 Michelson Lab., USNOTS, China Lake, Calif. Tel: 77882
Fourth Thursday, Meeting at 8:00 P.M., Michelson Lab, USNOTS.

CINCINNATI
R. J. Eichner, 1900 Courtland Ave., Norwood 12, Ohio. Tel: Jefferson 3130
Second Monday, Dinner at 6:30 P.M., Eng'r. Society Hqs.

CLEVELAND
G. D. Karnegie, 3436 Lorain Ave., Cleveland, Ohio.
Fourth Wednesday, Dinner at 6:30 P.M., Meeting at 8:00 P.M., Cleveland Eng'r. Society, E. 19th St.

COLUMBUS
E. H. Chandler, 91 E. Como Ave., Columbus 2, Ohio. Tel: JE 9994.
Third Thursday, Meeting at 8:00 P.M., Battelle Auditorium

CUMBERLAND
Clyde Babst, 225 Cecilia St., Gumberland, Md. Tel: 583-W
Tuesday after Fourth Monday, 8:00 P. M., Dinner at 6:30 P. M., Algonquin Hotel.

DETROIT
A. W. Brueckner, 5556 S. Clarendon Ave., Detroit 4, Mich. Tel: TYler 6-9511.
Third Tuesday, Dinner at 6:30 P.M., Meeting at 8:00 P.M., Rackham Bldg.

EASTERN NEW YORK
W. R. McKegg, c/o Gen. Engrg. & Consulting Lab., G. E. Co., Schenectady, N. Y.
First Tuesday, 8:00 P.M., Dinner at 6:30 P.M.

GULF COAST
W. N. Sloan, E. I. Du Pont de Nemours & Co., Orange, Texas. Tel: 8411 Ext. 444
Third Tuesday, Meeting at 7:30 P.M., Lamar College, Beaumont, Texas.

HOUSTON
I. K. Farley, 2123 Travis St., Houston, Texas, Tel: Charter 2511.
Last Monday, 8:00 P. M., Engineers Club.

KANSAS CITY
H. H. Schmall, 3706 Benton Blvd., Kansas City 3, Mo. Tel: AR 4808
First Tuesday, 7:30 P.M., U. of Kansas City.

LOUISVILLE
C. M. Bosworth, 203 Arbor Park, N., Lo., Ky.
Fourth Tuesday, Meeting at 8:00 P.M., Seagram Auditorium.

MONTREAL
L. E. Henne, Bristol Co. of Canada Ltd., Dominion Square Bldg., Montreal, Quebec, Can. Tel: UNiversity 6-4725.
Last Monday, 8:00 P. M., Mechanics' Institute.

NEW JERSEY
L. H. Ballinger, 2371 Channing Ave., Westfield, N. J. Tel: Westfield 2-0765M
First Tuesday. Meeting at 8:00 P.M., Essex House, Newark.

NEW ORLEANS
W. H. Haney, 2927 Music St., N. O. 22, La.
No Regular Date, Meeting at 8:00 P.M.

NEW YORK
F. B. Leslie, 8856 Commonwealth Blvd., Bellerose 6, N. Y. Tel: FI 7-0645
Last Monday, Dinner at 6:00 P.M., Meeting at 7:45 P. M., Hob Nob Club, 108 E. 41st St.

NIAGARA FRONTIER
Mrs. James L. Martin, 697 Potomac Ave., Buffalo 22, N. Y. Tel: GR 1450
Fourth Monday, Dinner at 6:30 P.M., Meeting at 8:00 P.M., N. Y. State Inst. of Arts and Sciences, Buffalo.

NORTH TEXAS
R. E. Byers, 6000 Lemmon Ave., Dallas 9.

NORTHERN CALIFORNIA
S. D. Stillson, 1324 Everett St., El Cerrito, Calif. Tel. Becon 2-7139
Third Monday, 8:00 P. M., E. Bay Area.

NORTHERN INDIANA
J. Baum Beckman, 547 N. Waller Ave., Chicago 44, Ill. Tel: ES 8-7776
First Wednesday, Meeting at 7:30 P.M., Whiting Community Center, Whiting, Ind.

OAK RIDGE
J. Lundholm, Jr., Eff. A-3, Apt. 214, Oak Ridge, Tenn. Tel: 5-6539
First Wednesday, Meeting at 7:30 P.M., Knight's of Columbus Hall.

ONTARIO
John W. Huether, 311 Southerland Dr., Leaside, Ontario, Canada. Tel: HU-7114
Third Thursday, Meeting at 8:00 P.M. Friendship Hall, College St. United Church, Toronto

PANHANDLE
W. F. Hoag, Phillips Chem. Co., Box 277, Dumas, Texas. Tel: 241.
Third Tuesday, Meeting at 8:00 P.M.

PHILADELPHIA
R. A. Trenner, Rm. 306, 3147 Broad St., Philadelphia 32, Pa. Tel: SA 2-7900
Third Wednesday, Meeting at 8:00 P.M., Bellvue Stratford Hotel.

PITTSBURGH
W. C. Langerman, Fisher Scientific Co., 711 Forbes St., Pittsburgh 19, Pa. Tel. Express 1-1330.
Fourth Monday, meeting jointly with the Technical Committee on Inspection and Gaging. Dinner at 6:30 P.M., Meetings at 8:00 P.M., Roosevelt Hotel.

PRESQUE ISLE
Edwin P. Schuwerk, 445½ Halley St., L. P., Erie, Pa. Tel: 2-3349
Fourth Tuesday, Meeting at 8:00 P.M., G. E. Community Center, East Lake Rd., Erie, Pa.

RICHLAND
R. A. Nederhood, 2003 Trippe St., Richland, Washington. Tel. 5-4442
Second Wednesday, Meeting at 7:30 P.M., American Legion Hall.

ROCHESTER
R. C. Schwarz, Jr., 1201 Granite Bldg., Rochester 4, N. Y. Tel: Monroe 4610R
Fourth Tuesday, Meeting at 8:00 P.M., Univ. of Rochester, Physics Lecture Hall.

SARNIA
L. J. Hall, 730 Talfourd St., Sarnia, Ont., Canada. Tel: EDgewater 2258.
Second Friday, 8:00 P. M., Moose Hall.

SOUTH MICHIGAN
W. J. Sprau, 2509 S. Rose St., Kalamazoo, Mich. Tel: 4-7012.
Fourth Wednesday, 8:00 P. M., Dinner at 6:30 P. M., Chicken Charlie's, Kalamazoo.

SOUTH TEXAS
H. C. Givens, La Gloria Corp., P.O. 637, Falfurrias, Texas. Tel: 122-W
First Wednesday. Meeting at 7:30 P.M.

ST. LOUIS
W. G. Lee, 4710 Delor St., St. Louis 16, Mo. Tel: FL 8516.
First Wednesday, Meeting at 8:00 P.M., Engineer's Club of St. Louis.

TOLEDO
P. H. Girkins, 418 Waggoner Blvd., Toledo 12, Ohio.
Third Tuesday, Meeting at 8:00 P. M., Service Bldg., Toledo Edison Co.

TENNESSEE
N. M. Taylor, 16 Edgewood, Kingsport, Tenn. Tel: 3338J
No definite night, Dinner at 6:45 P.M., Meeting at 8:00 P.M., Hall's Dining Rm., Bristol Hwy., Kingsport.

TULSA
S. M. Bagwell, 1544 E. 35th Pl., Tulsa 5, Okla.
First Monday, Meeting at 7:30 P.M., Engineering Bldg., Tulsa Univ.

TWIN CITIES
Alden Hine, c/o Pinkney & Hine, 552 Plymouth Bldg., Minneapolis 3, Minn. Tel.: Lincoln 0523.
Fourth Tuesday, Dinner at 6:30 P.M. Coffman Memorial Union, U. of Minn.

WASHINGTON
Raymond E. Miller, 20-224 Naval Ord. Lab., White Oak, Md. Tel: JU 7-6742
Third Monday, Meeting at 8:00 P.M., P. E. P. Co. Auditorium.

WAYNE COUNTY
J. R. McCaulev, 18073 Archdale, Detroit 19, Mich. Tel: KE 1-5239.
Third Monday, Meeting at 8:00 P.M., Larson's Cafe, Lincoln Park, Mich.

WILMINGTON
J. E. Charsha, Jr., Hammel-Dahl Co., 1000 Washington St., Wilmington 11, Del. Tel: 2-6694
Third Tuesday, Meeting at 8:00 P.M. Harlan Public School, Wilm.

Symposium on Boiler Instrumentation

The Philadelphia section of the ISA is sponsoring a symposium on "Boiler Instrumentation" to be held on Thursday, November 15, 1951 at the Bellevue-Stratford Hotel, Philadelphia. This will be an all-day conference with outstanding representatives of both instrument manufacturers and users to present technical papers and discussions on various phases of this subject.

Technical chairman of the symposium will be Mr. A. W. Thorsen, Supervising Engineer, United Engineers, Philadelphia, Pa. Technical papers, which will commence about 9:30 a.m., include:

1. "Modern Feed Water Control" by C. H. Barnard, Application Engineer, Bailey Meter Company.

2. "Design of Instrumentation and Control in a Modern Power Plant" by T. Y. Mullen, Engineering Department, Gilbert Associates, Inc.

3. "What the Boiler Designer Expects of Instrumentation" by H. C. Mittendorf, Chief Electrical Engineer in Charge of Control Design, Combustion Engineering—Superheater, Inc.

4. "Types of Combustion Control—Superheat and Reheat Controls" by E. D. Scutt, in Charge of Steam Power Section, Leeds & Northrup Company.

Each paper will be followed by prepared discussions by selected manufacturers and users.

An evening session starting at 8 p.m. will have a guest speaker to talk on the subject of "Instrumentation for the Power Plant of the Future". The Industrial Instruments and Regulators Division of ASME has been invited to attend this symposium and, of course, all guests interested in the general subject will be most welcome. A registration fee of $2.00 per person will be charged for the morning and afternoon sessions; registration starts at 8:45 a.m.

SECRETARY'S PAGE

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Instrumentation for Testing

Tuesday morning session

"The Negator in Instrumentation," by H. E. Mankonen (Hunter Spring Co., Lansdale, Pa.).

"Measurements in Tractor Design & Development," by R. P. Wehrle (International Harvester Co., Chicago, Ill.).

"Research vs. Industrial Instrumentation," by D. C. Little (Army Med. Serv. Field Res. Lab., Ft. Knox, Ky.).

Wednesday morning session

"Dynamic Modulus of Elastomers," by G. W. Painter.

"Instrumentation in Creep-Testing Laboratory," by J. Lundholm (Oak Ridge National Lab., Oak Ridge, Tenn.).

"Notes on Wire Strain Gauge Applications," by H. F. Rondeau (General Electric Co., . . .).

Instrument Maintenance & Operation

Monday morning session

"A Resume of Thermocouple Checking Procedures," by H. C. Quigly (DuPont Co., Wilmington, Del.).

"Instrument Installation Practices," by H. A. Hulsberg (Universal Oil Products Co., Chicago, Ill.).

Miscellaneous

Wednesday morning session

"An Electrostatic Micromanometer," by C. Spaulding (Consolidated Engineering, . . .).

"Servo-Mechanism Theory," by S. P. Higgins Jr. and G. W. McKnight (Minneapolis-Honeywell Reg. Co., . . .).

"Psychometric Methods of Quality Control," by E. H. C. Brown (J. E. Seagram & Son, Inc., Lawrenceburg, Ind.).

Friday morning session

"Instrumentation in Corrosive and Slurry Service," by P. D. Schnelle and R. K. Schmoyer (DuPont, Orange, Texas).

"The MiniPump," by R. Sheen (Milton Roy Co., Phila., Pa.).

ASME Industrial Instruments and Regulators Division Program

"A Multiple Input Totalizing System," by J. E. Bevins & G. S. Miles (Eclipse Pioneer Div. Bendix Aviation Corp., Teterboro, N. J.).

"Analysis and Synthesis of the Lateral Control Problem," by R. N. Bretoi (Aero Div. Minneapolis-Honeywell Reg. Co., Minneapolis, Minn.).

"Instrumentation in Exploration Geophysics," by R. D. Wykoff (Gulf Research & Development Co., Pgh., Pa.).

"The Modern Field Magnetometer," by W. Ruska (Ruska Instrument Corp., Houston, Tex.).

"New Precision Barometer & Barograph," by C. A. Heiland (Heiland Research Corp., Denver, Colo.).

"The Effect of Servomechanisms on the Future of Industrial Processes," Panel Discussion.

AIEE Geophysical Technical Group Program

"A.V.C. in Seismograph Amplifiers," by A. A. Chernosky (Humble Oil & Ref. Co., Houston, Texas).

"Seismometer Design and Construction," by Dr. J. T. Woods (Atlantic Refining Co., Dallas, Texas).

"Recent Developments in Instrumentation of Magnetic and Gravity Exploration," by Dr. L. L. Nettleton (Gravity Meter Exploration Co., Houston, Texas).

IRE Program

"Vibrotron Temperature and Pressure Measurements," by J. Ohman (Southwest Research Institute, San Antonio, Texas).

"Direct Measurement and Indication of Frequency," by P. M. Erlandson (Southwest Research Institute, San Antonio, Texas).

"A System for the Precise Measurement of Phase Angle over a Wide Frequency Range," by H. L. Gray Jr. (Technology Instrument Corp., Acton, Mass.).

"Recent Developments in Low Frequency Oscillators and Low Frequency Techniques," by L. W. Erath (SIE Research & Development Corp., Houston, Texas).

"A Low Frequency Function Generator," by R. Brunner (Hewlett-Packard Co., Palo Alto, Calif.).

"Telemetering in Well Logging," by W. J. Greer (Hallburton Oil Well Cementing Co., Houston, Texas).

"A Direct Reading VHF Frequency Meter," by L. S. Cutler (Gertsch Products Inc., Los Angeles, Calif.).

"Vacuum Tubes in Resistance Coupled Amplifiers," by L. G. Cowles (Superior Oil Co., Houston, Texas).

"The Magnetic Amplifier and Applications to Process Measurement and Control," by M. C. Clere (Wyatt C. Hedrick Eng'r. Corp., Houston, Texas).

"Atmospheric Index of Refraction Measurements at 9000 Megacycles," by A. P. Deam (Univ. of Texas, Austin, Texas).

AIP Program

"High Speed Computers and the Differential Equations of Mathematical Physics," by Dr. J. H. Curtiss (National Bureau of Standards, Washington 25, D.C.).

"Computers for Correlation Functions," by Dr. F. E. Brooks Jr. (University of Texas, Austin, Texas).

"Computer Applications at Northrup Aircraft, Inc.," by G. Toben (Northrup Aircraft, Inc., . . .).

"Low Temperature Physics," by Dr. C. F. Squire (Rice Institute, Houston, Texas).

"Physics and Exploration for Petroleum," by Dr. M. M. Slotnick (Humble Oil & Refining Co., Houston, Texas).

"Electron Diffraction Methods," by Dr. W. O. Milligan (Rice Institute, Houston, Texas).

Gulf Coast Spectroscopic Group Program

"Rearrangement Peaks in the Mass Spectrum of Ethylene Dichloride," by S. E. Cook (Ethyl Corp., Baton Rouge, La.).

"Calculation of Correction Patterns for Heavy Fractions in Mass Spectra," by M. L. Bollinger (Esso Standard Oil Co., Baton Rouge, La.).

"Sensitivity Fluctuations of Ammonia in the Model 21-102 Mass Spectrometer," by H. M. Davis (Esso Standard Oil Co., Baton Rouge, La.).

Texas A & M Symposium on Instrumentation for the Process Industries Program

"The Application of Continuous Infrared Analyzers," by J. M. Devine (Baird Associates, Cambridge, Mass.).

"Dielectric Measurements," by W. H. Howe (The Foxboro Co., Foxboro, Mass.).

"Optimalizing Systems in Process Control," by Dr. Y. T. Li (Massachusetts Institute of Technology, Cambridge, Mass.)

"Pneumatic Operators for Throttling Service," by Dr. D. P. Eckman (Case Institute of Technology, Cleveland, Ohio).

"Instrumentation of a Synthetic Rubber Plant," by J. S. Detwiler (Taylor Instrument Cos., Rochester, N. Y.).

"Instrumentation of an Oxygen Plant," by J. Arnold (Hydrocarbon Research Inc., N. Y., N. Y.).

"Refinery Control Problems," by E. D. Mattix (Cities Service Refining Corp., Lake Charles, La.).

The Pipe Liners Club Program

"Instrumentation in Long Line Gas Transmission Systems," by E. S. Plank (Tennessee Gas Transmission Co., . . .).

"Selection of Control Valves for Large Capacity Liquid Pipe Lines," by R. H. Putnam (Shell Pipe Line Corp., . . .).

The Program of the National Association of Corrosion Engineers is yet to be received. Titles of the papers of the RBD-NBS Symposium on Infra-red Instrumentation have yet to be received at this writing. The final program with complete list of papers and abstracts will be available in early September.

I hope you will stop in to see me in Houston. —Richard Rimbach

ISA EMPLOYMENT SERVICE

Forward your letter to INSTRUMENT SOCIETY OF AMERICA
921 Ridge Ave., Pittsburgh 12, Pa.

INSTRUMENT ENGINEERS. Graduate Mechanical, Electrical or Chemical, with several years industrial instrumentation experience for positions as Project Engineers handling design, purchase, and engineering on prefabricated process control panels. Unusual opportunity for men able to work on several projects and meet schedules. Interesting work with manufacturer of quality equipment. Location, Chicago, Ill. or Wilmington, Del. All replies confidential. Box 502.

INSTRUMENT ENGINEERS. Graduate Engineers. The applications section of the instrument dept. at Oak Ridge National Laboratory operated by Carbide & Carbon Chemicals Co. is being enlarged to provide instrument engineering for expanding programs. Work entails selection of proper instrumentation, design of components, design of panels, installation follow-up, writing of service specifications and service instructions. Give background data in first letter. Location Oak Ridge, Tenn. Box 503.

INSTRUMENT ENGINEER. Minimum 10 years experience repairing major makes and types of industrial controls, instruments and valves, plus minimum 2 years supervisory experience, including cost records and reports. Essentially able to coordinate and administer all repair shop operations, also perform and work for demonstration and training purposes. Group insurance and pension benefit plan in operation. Good salary and permanency for right man. Location Detroit, Mich. Box 504.

INSTRUMENT ENGINEER. Experienced in product development of medium and small precision clock mechanisms. Permanent position for right man. Write stating age, experience, and salary expectations. Location Connecticut. Box 505.

INSTRUMENT ENGINEER. Electrical Engineer experienced in electrical and mechanical design of motor-driven timing devices. Permanent position for right man. Write stating age, experience, and salary expectations. Location Connecticut. Box 506.

INSTRUMENT ENGINEERS. Needed immediately for Flight Test Instrumentation, Servomechanisms, Electronic Design by large aircraft manufacturer. Starting rate and future advancement commensurate with ability, experience and

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ISA EMPLOYMENT REGISTER

Sixth Annual Instrument Conference and Exhibit, Sam Houston Coliseum, Houston, Texas, September 10-14, 1951

Seeking a Position in Instrumentation? Registration forms and further instructions may be obtained from the Society Office. Registration by applicants may be made by mail to this office prior to opening of the Conference and Exhibit or may be made in person Sept. 10-14 at the Employment Register Desk, Sam Houston Coliseum. You do not have to be present. Prospective Employers may examine applications and make selection for mail or personal contact. Write now for application card.

Do You Need an Instrument Man? Companies or institutions seeking instrument men are requested to file notice of open positions with the Society Office, prior to the week of the Conference and Exhibit for posting on bulletin board. You do not have to be present. Interested applicants will be instructed to write direct to you.

INSTRUMENT SOCIETY OF AMERICA, 921 Ridge Avenue, Pittsburgh 12, Pa.

Quality Electronic Components for Instrument Circuits

By W. R. CLARK*

ABSTRACT.—Electronic circuits for instruments require components of higher quality than are used in the highly competitive radio field. Price is not as critical a factor as long life, dependability, ruggedness, stability, low noise level, etc. Suitable components will accelerate further the use of electronics in instrumentation. Cooperation between the component manufacturer and the instrument maker is essential.

Some failure of electronic components can be attributed to misuse by the instrument manufacturer. Proper choice of the correctly rated component for a particular application is of paramount importance in the industrial field.

Although component manufacturers during the past few years have improved some of their products considerably, many components still require considerable improvement.

Many mass-produced parts fall short of meeting the quality requirements of reliable instruments. Therefore, many instrument manufacturers find it necessary to make, or to have specially made for them, electronic circuit components which they would prefer to obtain from companies that regularly produce similar parts in large quantities.

The components referred to in this article are mass-production components which, with relatively little improvement, could meet instrument makers' requirements.

Resistors

The component used most extensively in electronic circuits is the resistor. Developments in recent years have led to the production of a large variety of types, including wire-wound power units, precise wire-wound units, woven-wire resistors, deposited carbon resistors, metal-film resistors and composition resistors.

WIRE-WOUND POWER UNITS are, generally speaking, satisfactory. However, there are many applications which require greater stability with changes in temperature than the wire-wound units provide. Miniaturization of electronic circuits requires the reduction of the size and weight of these units while retaining the same wattage dissipation, thus necessitating operation at higher temperatures. Temperature stability is mainly a metallurgical problem of obtaining better wire.

PRECISE WIRE-WOUND RESISTORS are affected by mechanical stress caused by fluctuating temperature, vibration, and moisture conditions. The higher the value of the resistor, the finer the wire, and the more vulnerable the unit is to failure. Sealed units are a big step toward elimination of failures.

WOVEN-WIRE RESISTORS are at present the best precise resistors for a-c. work. However, they have some of the same limitations as the precise wire-wound resistors.

DEPOSITED CARBON-FILM RESISTORS are offering some competition to precise wire-wound and woven-wire resistors. The stability of sealed units is good except for temperature coefficient. Although the coefficient is low (−200 to −500 parts per million per degree C.) it doesn't compare to that of the wire units. Carbon-film resistors have better high-frequency characteristics than wire units; however, these resistors can not be adjusted to the required accuracy as readily as wire resistors. The greater the accuracy required, the more difficult is the problem of adjustment.

Fig. 1 Input transformer for Speedomax recorder (1932).

METAL-FILM RESISTORS have the same advantages as the deposited carbon resistors.

Of all resistor types, COMPOSITION RESISTORS offer the most fertile field for improvement. An improvement by a factor of ten in stability would be most welcome—if it could be obtained without an equivalent increase in cost. The term "stability" includes aging, temperature, and humidity effects.

The field is wide open for a high-value resistor—1000 megohms—or greater—which is inexpensive and which has fair stability characteristics.

Rheostats

Many instruments require rheostats or voltage-dividing resistors (sometimes called potentiometers). These require improved resistance elements and also better mechanical moving parts. Like the fixed resistor, the composition-type rheostat is the most popular. This type requires improvement in stability for general-purpose use in reliable electronic circuits. Mechanical deficiencies in the terminals and in the sliding contact of both the composition types and the wire-wound result in limited life. Better insulation between the sliding contact and the shaft would be very desirable, and non-inductive rheostats would be of great assistance in some applications.

Transformers

Transformer development has been remarkable in the last twenty years. The availability of new core materials makes possible the achievement of high open-circuit inductances simultaneously with a high coefficient of coupling. For a given source impedance and load impedance, the low-frequency response is related directly to the open-circuit inductances exhibited by the winding. The high-frequency response is related to leakage inductance and distributed capacitance. The use of core materials with higher permeability permits a reduction in size of the transformer without changing its low-frequency response and with extension of its high-frequency response.

For low-power units, the cores are made of nickel alloys to obtain the widest pass band. For high-power units, the use of grain-oriented steel cores results in good performance at reduced size and weight. Powdered-nickel alloy is used for audio reactors or high-frequency transformers in which the coil and the core are small. Other materials such as Ferrite are useful at high frequencies.

A good example of progress in transformer development is the improvement of input transformers designed to operate at 60 cycles and to be free from magnetic pickup at low levels. An early transformer of this type, although large and bulky, made possible the marketing in 1932 of the first commercially available electronic recorder—the

THE AUTHOR

William Russell Clark received his B.S. degree in Electrical Engineering from the Moore School, University of Pennsylvania, in 1929. After spending two years in the Research Department of the Leeds & Northrup Co., he returned to the University of Pennsylvania and received an M.S. in Electrical Engineering. He was a member of the Museum staff of the Franklin Institute until 1934, when he returned to the Research Department of Leeds & Northrup. In 1938 he received his Sc.D. degree from the University of Pennsylvania. He is presently Assistant Chief of the Electrical Division of the Research Department, Leeds & Northrup Co. Mr. Clark has also been active in the AIEE. He has been a member of the Electronics Committee and the Instruments and Measurements Committee for several years, and is at present Chairman of the latter committee.

* Research Dep't, Leeds & Northrup Co., Philadelphia, Penna.

NOTE: Presented before the Fifth Annual Conference of the Instrument Society of America at Buffalo, N. Y., Sept. 18-22, 1950.

Statements and opinions expressed in these articles are those of the authors and not necessarily those of the Society.

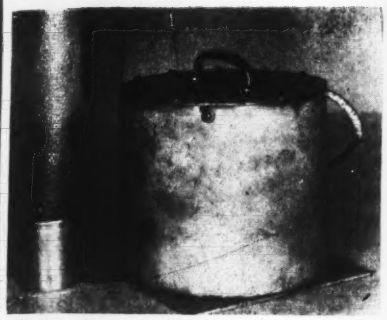

Fig. 2. New vs. old input transformers for recorders.

"Speedomax." This transformer (Fig. 1) had a secondary impedance of approximately 15 megohms and a turns ratio of 1:1000. Shell-type construction was used and magnetic pickup was minimized by three concentric iron shields.

In later recorders, a transformer has been used which occupies less than 1/10 the volume (Fig. 2). The later transformer does not have as high a secondary impedance nor as high a turns ratio, but it is capable of operation at power levels lower than the large transformer of earlier design. This has been made possible by the use of core-type construction (hum-bucking design) and quadruple concentric magnetic-shields of thin but effective high-permeability nickel alloy (Fig. 3). Leeds & Northrup had to manufacture these transformers because transformers available on the open market did not have the desired characteristics—particularly freedom from magnetic pick-up.

POWER-SUPPLY TRANSFORMERS currently available are adequate for most electronic circuits.

CHOKES for use in low-level filter circuits present the same problems as do the low-level input transformers.

Special impregnants have been a big help for operating transformers or chokes in atmospheres which would attack the wire. Previous practice has been to hermetically seal such transformers in cans. This results in additional size and weight. Polymerizing resins which have low viscosity and which require no solvent have been developed. The resins change from a liquid to a solid state with only a slight change in volume.

Capacitors

Next to resistors, capacitors are the most widely used component in electronic circuits. If all capacitors were pure capacitance, there would be little need to discuss the electrical performance of these units. However, as capacitors are a combination of pure capacitance, residual series-resistance, parallel conductance, series inductance, and, in many cases, a source of spurious current, it is necessary to check each application to make certain that the proper capacitor is chosen.

Except for electrolytic capacitors, the commercially available capacitors for by-pass, coupling, lead-through, and filter applications are fairly satisfactory. The electrolytic capacitor, in spite of the recent development of the 85 C. units, still needs improvement to permit operation at higher temperatures, to obtain greater shelf life, and to reduce absorbed charges. This type capacitor is of particular importance in low-frequency amplifiers and power supplies because paper capacitors are too bulky and expensive for these applications. Metallized paper capacitors have been of great assistance in reducing the size of capacitor components, but, although they are a good substitute for paper capacitors, they are too bulky and expensive to replace the electrolytic.

A problem becoming more pressing every day is the choice of input filter capacitors used in high-speed recorders and in instrument amplifiers designed for sensitivities of a fraction of a microvolt or a few micromicroamperes d-c. A relatively high value of capacitance is required, but the use of electrolytic capacitors is impossible because of their high leakage-conductance and their tendency to act as an electrolytic cell, developing a voltage many times greater than the required sensitivity. Oil- or wax-impregnated units are considerably better, but they take too long to stabilize when the instrument response must be

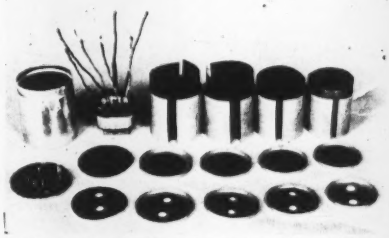

Fig. 3. Construction of new type input transformers.

less than one second. The polystyrene capacitor is superior to the paper capacitor, but it also can give spurious currents in excess of 10^{-12} ampere under adverse conditions. The effect of these various capacitors on recorder response is shown in Fig. 4.

Leeds & Northrup designed the equipment for measuring these small absorbed charges and made that equipment available to the component manufacturer so that he could make units to meet the specifications.

One application required that the capacitor be noninductive. As none of the then-existing capacitors were sufficiently noninductive to be suitable, our company had to show the component manufacturer how to make these units.

Lead-through capacitors seem to develop a high leakage-conductance after extended operation at high temperature. This is particularly undesirable when they are used in relatively high-resistance circuits because they then act as low-resistance shunts.

In critical applications requiring (1) absolute accuracy of adjustment, (2) short- and long-term stability, (3) low dielectric-loss, and (4) low temperature-coefficient, the usual procedure is to use a high-quality air capacitor for capacitance values below 1,000 uuf., and mica units above 1,000 uuf. There has been, however, a wide gap between the quality of air and mica components, resulting in relatively inaccurate measuring and calibrating equipment for capacitance values of 1,000 uuf. and higher. Work done at L&N indicates that hermetically sealed silvered mica capacitors can do much to narrow this gap.

Printed Circuits

Printed circuit components are still in the research stage. For volume production, they permit a reduction in the size and the cost of instruments. However, certain of their characteristics must be improved in order that these components can be used generally in instruments. At present they are of value in some high-frequency circuits, a notable example being interstage resistance-capacitance coupling units, but they are not of much value in low-frequency circuits. Their general usefulness is limited because of lack of stability, reduced accuracy, limited reproducibility of units, and restricted range of values.

There has been a great improvement in the design of CONNECTORS, including tube sockets, within the past few years, but there are still no low-leakage connectors available on the open market suitable for high-impedance circuits, such as those used for the determination of pH by means of the glass electrode.

Switches

The switches available on the present-day market are suitable for radio and television service, but not for precise instruments. Some designs which come close to meeting the desired specifications fail because of high contact-resistance which, while not present when the switches are new, develop with continued use. Low insulation between contacts is another objection. Better contact material and better switch insulation would produce a switch suitable for many instrument applications.

Leeds & Northrup has had to develop and manufacture its own switches in order to obtain units with the desired characteristics. Several types have been made. One switch (Fig. 5), which is similar to present radio switches, has high insulation between contacts, low contact-resistance, low contact-emf., and long life. An enclosed general-purpose type (Fig. 6 and 7) is a multiposition,

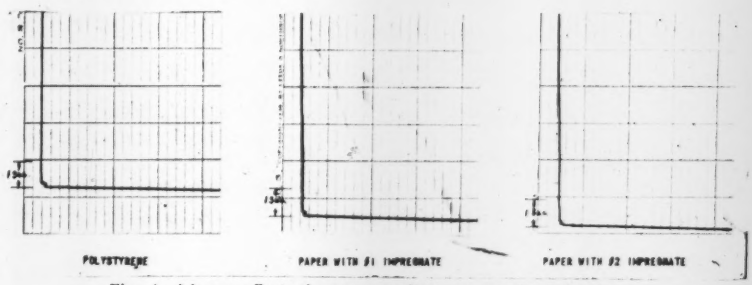

Fig. 4. Adverse effect of poor capacitor on recorder balancing.

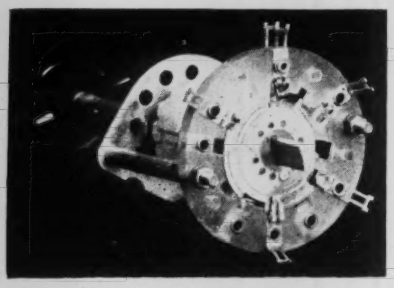

Fig. 5. High insulation-resistance, low contact-resistance switch.

multiple-selector switch which is suitable for use in resistance or capacitance decades.

Other instrument companies have developed switches to meet their specific needs.

Vacuum Tubes

The most vulnerable part of electronic equipment is the vacuum tube. Electron-tube failures and the possibility of failures retard the application of electronic equipment. This is especially true for unattended industrial use requiring continuous operation 24 hours a day for 365 days in the year. A longer average life-span for tubes would help this situation, but a means of detecting and eliminating tubes liable to premature failure would be of even greater help. The development of new long-life ruggedized tubes by various tube manufacturers has been a big step in the right direction. Longer tube life is not needed as urgently for test instruments used only intermittently.

The trend in instrument designs of all types seems to be to smaller size and weight. Hence, miniature tubes are becoming more popular.

Next to long life, the most important item is reproducibility of characteristics between tubes of the same type. Low power consumption is desirable for tubes used in battery-operated instruments. Even in line-powered industrial instruments, it is desirable to keep the wattage low in order to keep the operating temperature of the instrument to a minimum.

New voltage-regulating tubes are more free of discontinuities in operating voltage than are the older regulator tubes used in regulated power supplies; a reduction of the temperature coefficient of these tubes would be helpful.

The reduction of dark current in photomultiplier tubes has been of great assistance to the instrument manufacturer.

New low-cost rectifiers are replacing rectifier tubes in some applications. Metallic rectifiers permit easier isolation of the power supply because they do not require a heater potential, as do vacuum tubes. Because of their much longer life, they need not be mounted in an accessible place.

Conclusion

Generally speaking, the instrument manufacturer has two main sources for quality electronic components. He can either produce the component himself, or he can work with a cooperative manufacturer of components.

The development of quality components is sometimes forced on the instrument manufacturer, which has resulted in his entering the components market.

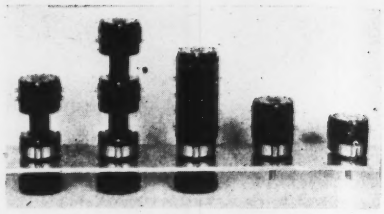

Fig. 6. Enclosed general-purpose switch.

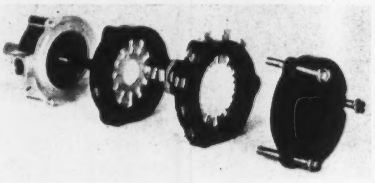

Fig. 7. Parts for general-purpose switch.

Often in the development of new and improved components, special test equipment has to be developed by the instrument manufacturer. This equipment becomes available to the cooperating component manufacturer much earlier than it appears on the open market.

As the instrument manufacturer is doing part of the research work in producing the new component, he is saving the component manufacturer considerable time and money. This mutually beneficial procedure also permits the cooperating component manufacturer to lead the field in marketing new and improved components.

A CERAMIC ACCELEROMETER of Wide Frequency Range

By LAWRENCE T. FLEMING*

ABSTRACT. An experimental miniature transducer has been developed for vibration measurements, whose output is essentially flat from a few cycles to 15 kilocycles. The generated output voltage is proportional to the applied acceleration. The instrument utilizes the reaction of a small mass against a disk of "piezoelectric" barium titanate. Weight of the pickup is about 3 grams and the sensitivity about 2.5 millivolts per g. (acceleration due to gravity). The internal impedance is a capacitance of approximately 0.001 mfd. Methods and apparatus for calibration are discussed.

Existing vibration pickups of the seismic type are not generally useful above about 1000 cycles per second. Investigations have been made at this laboratory with the purpose of extending the range of practical vibration measurements to the vicinity of 10 kilocycles. It was found that a most practical form of transducer for this purpose is a piezoelectric accelerometer of small physical size and simple, massive construction.

* National Bureau of Standards, Washington 25, D. C.

NOTE: Presented before the Fifth Annual Convention of the Instrument Society of America, at Buffalo, N. Y., Sept. 18-22, 1950.

The employment of piezoelectric crystals for measuring acceleration is by no means new.[1, 2, 10] Ammonium dihydrogen phosphate (ADP) has usually been used as the sensitive element. Unfortunately the fabrication and cementing of such material requires rather elaborate facilities and a good deal of specialized skill, and careful casing and protection.

With the advent of barium titanate as a stress-sensitive material, it has become possible to build a simple and effective accelerometer with ordinary shop facilities at low cost. Consideration of the effects of scaling the dimensions of such a transducer indicates that small sizes are more efficient when the transducer operates into a high impedance circuit, i.e., a vacuum tube. In addition, a small accelerometer can be calibrated on a small electrodynamic vibrator, which in turn can be made usable to higher frequencies than a larger vibrator. An incidental advan-

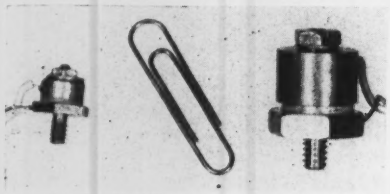

Fig. 1. Barium titanate accelerometer.

THE AUTHOR

Lawrence Fleming graduated from the California Institute of Technology in 1937. He was employed as an Examiner in the industrial electronics art in the U. S. Patent Office from 1937 to 1941. From 1941 to 1948, he was engaged in electronic and acoustical apparatus development at the Naval Ordnance Laboratory becoming a group supervisor in 1944. He was appointed to the staff of the National Bureau of Standards in 1948 as an electronics engineer. He has contributed articles to many periodicals and is a Senior Member of the Institute of Radio Engineers.

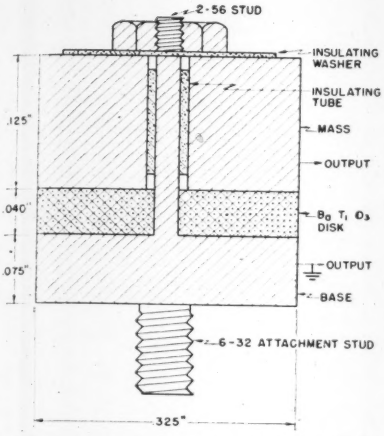

Fig. 2. Sectional drawing of barium titanate accelerometer.

tage of a piezoelectric accelerometer is that it can be actuated by an electromagnetic vibrator without having spurious voltages induced in it by the magnetic field of the vibrator coil.

Fig. 1 is a photograph and Fig. 2 a sectional drawing of a barium titanate accelerometer which is free from resonance effects up to at least 15 kilocycles. The sensitivity is about 2.5 millivolt per *g;* the capacitance, about 1000 uuf. It is suitable for measuring accelerations in the range, 0.5 to 500 *g* (*g* is the acceleration of gravity). The upper limit is not well known, but is over 1000 g.

Construction

The device comprises merely a suitable base (Fig. 2), a disk of "piezoelectric" barium titanate, and a mass attached thereabove. The disk is silvered on opposite faces. All mating surfaces are lapped flat. The whole is held together under a few kilograms pressure by means of a small central stud. Clearance holes are drilled through the mass and the disk. As a means of holding the parts together, the central screw was considered somewhat better than a hollow case, because a case tends to increase the total mass and the number of resonances. Flatness of the mating surfaces is very important, to prevent breakage of the ceramic.

The voltage generated is proportional to the instantaneous pressure on the disk. This pressure is simply the reaction of the mass to any acceleration imparted to the base, at any frequency below the region of resonance of the structure. The sensitivity agrees well with that calculated from the properties of the ceramic.[3]

Disks of pure barium titanate have been used, as well as a mixture containing four percent lead titanate.[4] No deterioration in sensitivity of the former has been noticed over a period of several months, although the latter should be more permanent.

Components and Assembly

The metal parts are made on a lathe. The barium titanate disks were made in the Ceramics Section of this Bureau. Commercial suppliers have indicated the ability to manufacture such disks, the cost depending on the quantity required. The silver coating is applied by brushing on DuPont No. 4731 silver paint, then baking in a furnace at 1300 F. for about 15 minutes. The central hole was made by the usual procedure for drilling holes in glass. The disk must be lapped flat, else it may crack when assembled.

Commercial phonograph pickup cable (about 0.07-inch diameter over the braid) is a convenient material for the output lead. The cable is soldered directly to the appropriate parts of the accelerometer structure. Soldering must be done before the pickup is assembled, so that the heat will not depolarize the ceramic.

Recommendations vary for polarizing or sensitizing this ceramic. The procedure used here comprises cooling the material down through its Curie point of 120 C. while a d-c. potential gradient of about 10,000 volts per centimeter is applied across the faces of the disk. This is conveniently done after the whole device is assembled. For a 0.060-inch thick disk, about 750 volts d-c. is applied to the connecting cable while the accelerometer is immersed in a beaker of silicone fluid on a hot plate. The fluid is heated to about 140 C., then the hot plate turned off. The accelerometer is removed from the bath after about an hour. This heating procedure was found to increase the sensitivity of the instrument two to three times over that obtained with polarization done at room temperature.

Calibration with Vibrators

Steady-state calibration of such transducers at frequencies above 1000 cycles is difficult by direct measurement of amplitude because the displacements involved are so small, although measurements of this sort have been reported, using elaborate apparatus.[5] Efficiency as a vibration generator is too low to permit calibration by the reciprocity method[6] or to locate resonances by noting the variation of impedance.

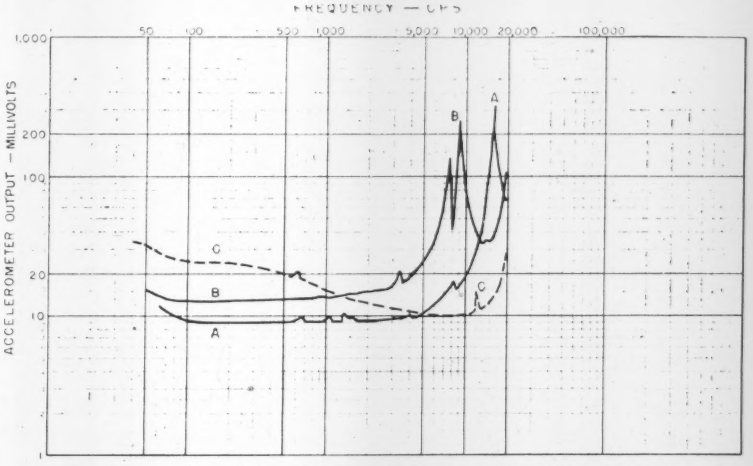

Fig. 4. Frequency response of same accelerometer on three different vibrators.

An indirect method was employed in which the accelerometer was excited by a vibrator of the electrodynamic ("loudspeaker") type. Ideally, such a vibrator produces the same acceleration at any frequency when the driving current to the voice coil is kept constant. The ideal case assumes that the whole moving system of the vibrator behaves as a pure mass. In commercial vibrators this holds approximately true to about 1000 cycles, above which rather violent resonances appear. By making the moving system of a simpler and more rigid shape, it was found possible to extend the frequency of the first significant resonance point to 18 kilocycles.

Fig. 3 is a photograph of an experimental vibrator used for accelerometer calibration. The field magnet and polepiece structure was taken from a large dynamic loudspeaker. The moving element is an inverted cup of phenolic material, with the driving coil wound in a shallow slot at its lower end. The thick top and tapered walls are an important factor in raising the frequency of self-resonance. The greatest source of resonances in commercial vibrators is the rod attached to the

Fig. 3. Experimental vibrator for accelerometer calibration.

driving coil form which extends through the pole structure and to which the supporting springs for the moving system are attached. Longitudinal resonance of this rod usually leads to a peak of about 20 db in the response, in the vicinity of 2500 cps. Fig. 6 is a sketch of the cup in cross-section.

In the small vibrator shown in Fig. 3, the rod is omitted, and the parallel cantilever support springs are both located above the pole structure. Resonant peaks due to these springs are small and easily damped out, because the mass of the springs is small compared to the mass of the cup.

Fig. 4 shows response curves of the accelerometer on three different vibrators. Current to the vibrator drive coil was maintained constant over the frequency range. All vibrators used the same pole structure, but different driving coil structures. Curve A was taken with the tapered-wall phenolic cup shown; Curve B, with a straight-sided cup; and curve C, with a tapered, slotted aluminum cup. The downward trend of C is due to eddy current losses, which is the reason why a metallic cup cannot be used, even with a slot.

The salient point is that all the curves are different, all are sensibly flat (as theory predicts) up to a certain high frequency, and that the high-frequency peak depends on the construction of the vibrator cup. It may be logically inferred that the shape of the curves are functions of characteristics of the vibrator rather than of the accelerometer.

A frequency run comparing the curve of a $BaTiO_4$ accelerometer with an entirely different method of acceleration measurement is shown in Fig. 5. A commercial vibrator was used which had a built-in calibrating coil. The output voltage of the coil is proportional to the velocity of motion. The ordinates of the original calibrating coil curve were multiplied by a factor proportional to frequency, yielding a curve whose ordinates are proportional to acceleration. This curve was then shifted vertically (but not along the frequency axis) to coincide with the accelerometer curve at 50 cycles, so that the two could be compared. Agreement within 20 percent is found up to 4800 cycles.

Above this frequency the curves become too jagged for such processing. Experience with vibrator construction would indicate that in that frequency range the accelerometer is no longer executing the same motion as the calibrating coil, due to the effect of compliances and resonances in that part of the structure connecting the calibrating coil and the accelerometer.

Accelerometer Resonance

A resonance test was made in which an accelerometer was mounted on a ¾-inch cubical steel block, which was then impacted by a small steel ball. A damped oscillation at 35 kc. was recorded, which is probably the resonant frequency of the accelerometer. No lower frequencies were found.

It is important that the pickup be screwed reasonably tight to the object under study, and that the base be well seated. To permit this, the base stud is undercut above the threads. A damped oscillation at 5 kc. was recorded in a case where there was about $\frac{1}{32}$-inch clearance between the base of the transducer and the block to which it was attached. The frequency rose to 35 kc. when the transducer was tightly seated on the block.

Absolute Calibration

The absolute level of acceleration is conveniently established at a low frequency where the amplitude is large enough to be conveniently measured optically. The relation is

$$g = (2x_0 f2)/19.56$$

where g is the acceleration expressed as multiples of the acceleration of gravity, $2x_0$ is the peak-to-peak amplitude in inches, and f is the frequency in cycles per second. The frequency at which this measurement is made should be adequately far above the low frequency resonance of the vibrator.

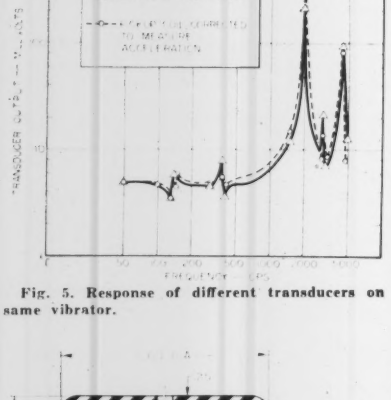

Fig. 5. Response of different transducers on same vibrator.

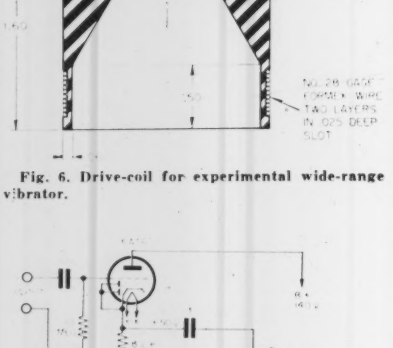

Fig. 6. Drive-coil for experimental wide-range vibrator.

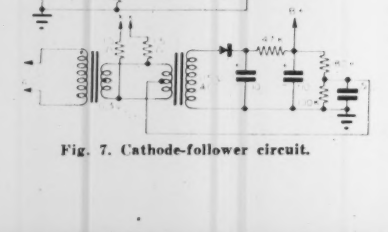

Fig. 7. Cathode-follower circuit.

The response of this transducer to lateral motion is about one-third of the response to axial motion. Further investigation on this question is planned.

Input Circuit Considerations

The effect of input circuit resistance and capacitance on the frequency response of this sort of accelerometer is the same as with any other capacitance source, such as a crystal microphone or phonograph pickup.

The low frequency limit depends on the ratio of the pickup capacitance to the input resistance of the amplifier to which it is connected. For a 1000 uuf source, if the input resistance is 10 megohms, the response will be down 3 db at 16/cps., where the reactance of 1000 uuf equals 10 megohms.

When a commercial electronic voltmeter with an input impedance of around 0.5 megohm is used to measure the output of the pickup at frequencies below 500 cycles, it is necessary to use a cathode follower or a pre-amplifier having a high input impedance. Commercial units are available, or one may be built.

The circuit of a suitable follower is shown in Fig. 7. The only precaution necessary in construction is to shield the grid circuit from a-c./electrical fields. The background level is about 0.5 millivolt; the maximum signal output capacity, 20 volts.

Electrostatic shielding over the accelerometer itself is sometimes necessary for low-level measurements in locations where stray 60-cycle fields are strong.

For applications requiring long cable runs it is sometimes feasible to use two-conductor shielded cable as a 200-ohm balanced line, with transformers at each end. Commercial line-to-grid transformers are satisfactory. The low frequency limit will depend on the ratio of source capacitance to the inductance of the high-impedance winding of the transformer, and is usually of the order of a few hundred cps.

Acknowledgement.—Credit is due Mr. Edmond J. Regan, who carried out the design and testing of all the accelerometers and devised the special techniques and selections of materials and processes necessary for successful results. The vibrators described were designed by Mr. Jerome D. Rosenberg. Mr. Elmer Ellsworth built the special auxiliary electronic equipment used.

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APPENDIX

For convenience, the relationships between displacement, velocity, and acceleration are set forth, together with a discussion of some fundamental considerations of vibration pickup design.

List of Symbols

In any consistent system of units,

x = displacement
v = velocity
a = acceleration
x_0 = peak displacement
v_0 = " velocity
a_0 = " acceleration
f = frequency
$w = 2\pi f$
t = time

For a sinusoidal vibration represented by

$$x = x_0 \sin wt,$$

the velocity

$$v = \frac{dx}{dt} = wx_0 \cos wt$$

and the acceleration

$$a = \frac{d^2x}{dt^2} = w^2 x_0 \sin wt$$

Where x = the relative displacement of the moving body, and
Where x_0 = the peak amplitude,
the peak velocity $v_0 = 2\pi f x_0$
and the peak acceleration
$a_0 = 4\pi^2 f^2 x_0$

In English units, where $2x_0$ is the *peak-to-peak* amplitude in inches, and f the frequency in cycles per second,
Peak velocity $v_0 = 2x_0 3.14\ f$ inches/sec.,
Peak acceleration $a_0 = 2x_0 19.74\ f^2$ in/sec.^{2}
The peak acceleration in g's is

$$g = \frac{2x_0 f^2}{19.56}$$

where g is the peak acceleration in multiples of the acceleration of gravity, $2x_0$ is the peak-to-peak amplitude in inches, and f is the frequency in cycles per second.

Table 1 shows in convenient form the interrelations between displacement, velocity, and acceleration as functions of frequency.

Types of Pickups

Vibration pickups in general can be divided into two general classes: (1) those in which the voltage or current output is proportional to a relative stress or displacement between two parts of the pickup:—strain gages, capacitive pickups, carrier types, and piezoelectric pickups, and (2) those in which the output is proportional to the relative velocity of two parts of the structure, i.e. those using an electromagnetic principle. Each type can have a resonant frequency below the range it is desired to measure (mass-controlled), or can have its response controlled by heavy viscous damping (viscosity-controlled) or can have its resonance above the desired range (stiffness-controlled). A pickup whose frame is attached to a stationary support separate from the object under test, has the same behavior as a mass-controlled pickup, operating above its resonant frequency.

Table II indicates the response characteristic of the various possible types. Practical pickups are of Types 1-a, 1-c, and 2-a. Viscosity control is only practical at very low frequencies; fluid damping is not too practical except to bring down resonant peaks, because of the large temperature coefficient of viscosity of available fluids. Type 2-c has no particular application at present because of its inherent response, except perhaps at very low frequencies, to measure "jerk" in vehicles.

A signal voltage proportional to any component of vibration can be derived from a pickup output that is proportional to another component by means of differentiating or integrating circuits. A voltage proportional to velocity can for example be derived from an accelerometer output by means of an r-c. integrating network.

The accelerometer here described is of Type 1-c: the output voltage generated is proportional to the stress (or strain) between the faces of the piezoelectric disk, and this stress is determined by the mass and dimensions of the structure, and the elastic constants thereof. The resonant frequency of the combination of the top mass (Fig. 2) and the compressive stiffness of the ceramic disk, is above the range being measured.

A factor in choosing the development of an accelerometer of Type 1-c as a means of exploring high frequency vibrations was the fact that such an exploration should include a suitable source of vibration; and the only practical wide-range source is an electromagnetic vibrator, which is inherently a constant-acceleration device. Another factor is that at high frequencies the amplitude for a given acceleration becomes very small indeed. Structures which are apparently rigid are deflected a few microns by surprisingly small forces. Extreme rigidity was, therefore, required, as well as simplicity of structures. All this favors the accelerometer structure described, which has no moving parts at all beyond its own elasticity.

Table I.—Interrelations between Amplitude, Velocity, Acceleration, and Frequency.

Variable Considered	*Displacement held constant*	*Velocity held constant*	*Acceleration held constant*
Displacement varies as	—	1 / f	1 / f^2
Velocity varies as	f	—	1 / f
Acceleration varies as	f^2	f	—

Table II.—Classification of Possible Kinds of Vibration Pickups

Type	*Output voltage proportional to*
1. Displacement-Responsive	
a. Mass-Controlled	Displacement
b. Viscosity-Controlled*	Velocity
c. Stiffness-Controlled	Acceleration
2. Velocity-Responsive	
a. Mass-Controlled	Displacement
b. Viscosity-Controlled*	Acceleration
c. Stiffness-Controlled*	(acceleration) × (frequency) or $\frac{d^3x}{dt^3}$

* Not in practical use.

Dimensional Scaling

An important question in the design of a device of this sort is what size is most efficient for the purpose. So it is well to consider what the effect will be of doubling or tripling the height and diameter, keeping ratio of these dimensions the same.

The open-circuit voltage generated by the crystal in simple compression is directly proportional to the unit pressure applied (dynes per sq. cm.) and also directly proportional to its thickness. The capacitance varies directly as the area (radius squared) neglecting edge effects, and inversely as the first power of the thickness.

Hence if all dimensions of the transducer are doubled, the open-circuit voltage is quadrupled, since the unit pressure (due to the larger top mass) and the crystal thickness have both doubled. The capacitance is doubled, because the area has quadrupled and the thickness doubled. The mass of the transducer will have increased by a factor of eight.

These considerations may be stated this way:

Scaling all dimensions of the whole accelerometer by a factor K will give a change in capacitance by the factor K, a change in output voltage by K^2, and of course a change in total mass by the factor K^3. Thus for simple scaling the output voltage per unit mass is an inverse first power function of the mass. The generated charge CV is proportional to the mass.

If we scale the thickness of the ceramic K^2, and all the other dimensions by K, the open-circuit voltage varies directly as the mass, or K^3; the capacitance remains constant. This type of scaling is more desirable when the cable length from transducer to amplifier is not over a few feet, as then there is usually no advantage in increasing the capacitance beyond 1000 uuf or so.

It is desirable to keep the over-all proportions about as shown, with the diameter roughly equal to the height.

A tall, thin shape would invite resonances due to lateral cantilever deflection of the structure.

Small cylindrical elements of barium titanate[5] have been tried, since they offer a possibility of increased sensitivity per unit mass. Fragility and difficulty of mounting have, however, been a serious problem, when attempts were made to load the top of the cylinder with a suitable metallic mass. The difficulties should be less with thicker cylinders, which were not tried. With small bodies, assembly by means of cementing or dental filling techniques would bear investigation. A single cylinder, ¼-inch in diameter by ½-inch high, with an 0.020-inch wall thickness merely cemented to a base with no top loading, has been found to make a good accelerometer having a sensitivity of the order of 0.3 millivolts per *g*.

ISA EMPLOYMENT SERVICE

Continued from page 965

background. Excellent working conditions and liberal employee benefits, a future with a progressive company. Send resume of training and experience. Location St. Louis 3, Mo. Box 507.

INSTRUMENT ENGINEERS. With experience in application, selection, installation and maintenance of measurement and automatic control equipment in wide variety of chemical processes. Must travel to plant locations for start up assistance, diagnosis of plant instrumentation problems and training of plant instrument forces. Working knowledge of process control theory as applied to pneumatic systems is desirable. Give education, experience and salary desired in first letter. Location Wilmington, Del. Box 508.

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INSTRUMENT TECHNICIANS. For aircraft instrumentation. Starting rate and future advancement commensurate with ability, experience and background. Excellent working conditions and liberal employee benefits, a future with a progressive company. Location St. Louis 3, Mo. Box 514.

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GOVERNMENT SERVICES

INSTRUMENTATION SCIENTISTS. A program in basic instrumentation research is underway at the National Bureau of Standards cooperatively sponsored by ONR, Air Force, and AEC, involving theoretical and experimental research, development, design, evaluation, and technical reference work in the broad field of measurement and control instruments. Excellent opportunities are open for qualified scientists and engineers in a broad variety of basic instrumentation problems. Salaries range from $3825. to $7600. per year. Further information concerning these positions can be obtained from W. A. Wildhack, Chief, Office of Basic Instrumentation, National Bureau of Standards, Washington 25, D. C.

To apply for any of the following Federal Agency positions, secure Standard Form 57, "Application for Federal Employment" from your local Post Office or write for the form to the agency involved. Complete the form and mail direct to the personnel office of the agency holding the vacancy.

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ELECTRONIC ENGINEER, $4600. Design, test and evaluation of electronic scientific instrumentation used in physical measurements.

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ELECTRONIC ENGINEER (2), $4600. Electronic research and development in the field of measurement.

ELECTRONIC ENGINEER, $4600. Design and development of electronic instruments for use in free flight ballistic experiments on Fin Stabilized rockets. Specialized experience in telemetering equipment is desirable.

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TECHNICAL SOCIETIES

SOCIETY FOR APPLIED SPECTROSCOPY

Tuesday, September 11, 6:00 p.m. Informal dinner, Tosca's, 118 Fulton St., New York. (No reservation necessary). 8:00 p.m. Business Meeting, Socony-Vacuum Training Center, 63 Park Row, N. Y. There will be no formal speaker, but plans for the coming year will be outlined by the new officers and committees.

New officers and their company affiliations include the following: Chairman—Rodger W. Loofbourow, Merck & Co., Inc.; Vice-Chairman—Dr. E. J. Rosenbaum, Sun Oil Co.; Secretary—Charles Jedlicka, Lucius Pitkin, Inc., 47 Fulton Street, New York 7, N. Y.; Treasurer—Charles H. North, National Lead Co., Titanium Div.

GAFTON L. CRUMRINE, North American Smelting Co., Marine Terminal, Wilmington 83, Delaware.

PITTSBURGH DIFFRACTION CONFERENCE

The Ninth Annual Pittsburgh Diffraction Conference will be held at Mellon Institute, Pittsburgh 13, Pa. on November 29 and 30, 1951. Sessions are tentatively being arranged on *Instrumentation and Methods*, and *Metals and Alloys*. Papers are solicited on these and related subjects, and will be considered in the order in which they are received. Titles should be sent to the Program Chairman, Mr. R. W. Turner, Carnegie Institute of Technology, Pittsburgh 13, Pa., before September 1.

The Conference will also include a symposium of invited papers on the subject of *Diffraction and Thermomagnetic Studies of Reactions of Metastable Carbides of Iron*.

For further information, and for a copy of the preliminary program when available, write to Mr. C. W. Cline, Aluminum Research Laboratories, P. O. Box 772, New Kensington, Pa.

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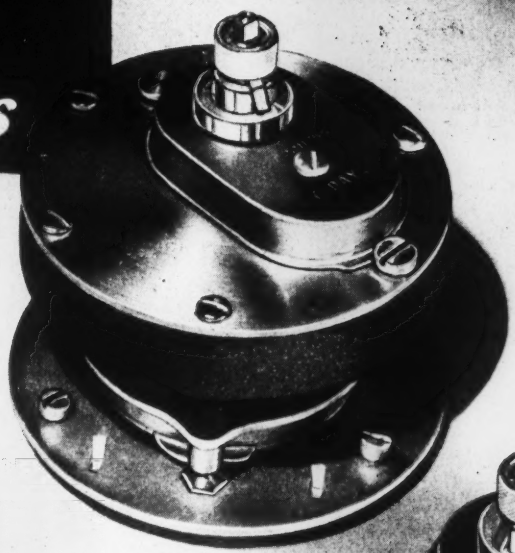
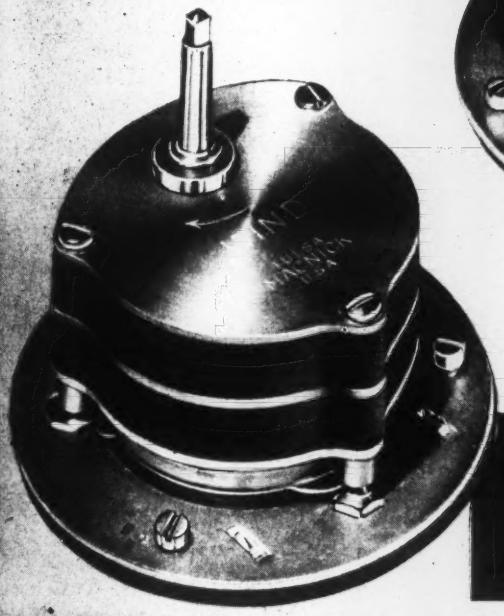
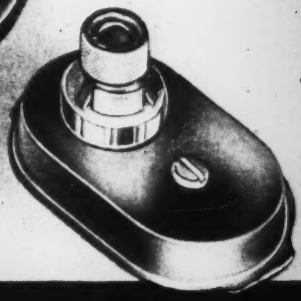


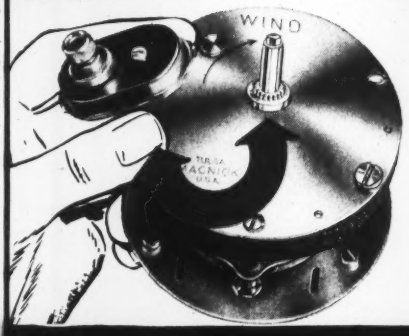




SHOWN ACTUAL SIZE

Left to right: Rockwell 24 hour wind and 8 day wind midget mechanical drives with rotation-converting Turret that, on the eight day model, permits one basic drive to be adapted to as many as 11 different speeds.

Specialists in precision drives for Meter, Control Devices



THE TURRET ON TOP *does the trick!*

The above illustration shows how Turrets lock onto the chart arbor of the eight day model to change rotation speeds. The eight day drive is basically 24-hour rotation. Turrets are available for chart rotation times of 2, 3 4, 6, 8, 12 and 48 hours; 3, 7 and 8 days.

THE MOST CHART DRIVE IN THE LEAST SPACE

Rockwell Midget Chart Drives fill the need for compact, powerful mechanical drives in instruments where space is at a premium. They are strongly constructed with cases of die cast aluminum, gears mounted in phosphor bronze bearings and an escapement case made of stainless steel and clear plastic. This escapement snaps into place without tools and is readily replaceable.

Rockwell Midgets wind through the chart arbor. They snap into a separate mounting ring only 3¼" in diameter which may be positioned on bosses or adaptors to fit any instrument case.

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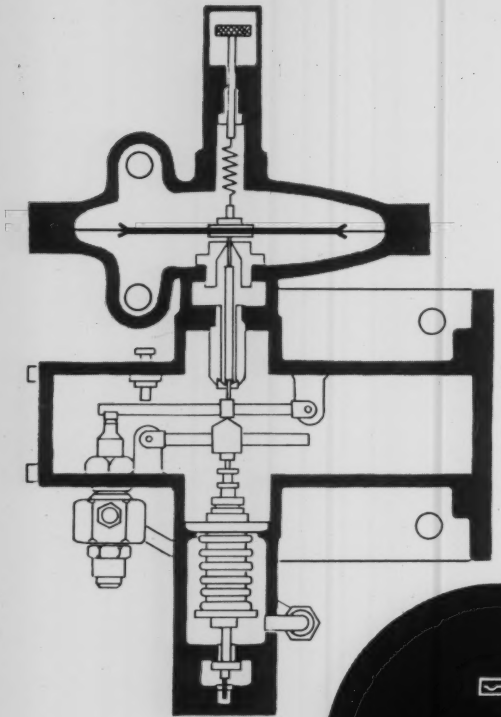

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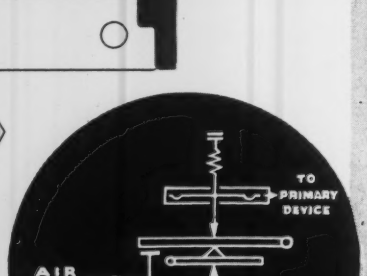

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The signal from the primary device is applied to the Askania diaphragm. It is then transmitted to a modulating valve which proportions the loading signal over the standard range of 3 p.s.i. to 15 p.s.i.

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Measurement *of* Flow *of* Fluids *through* Orifice Meters

with Particular Reference *to the* Measurements *of* Liquids *and* Steam

By WILLIAM L. COWAN, Union Oil Company

This is the second installment of Mr. Cowan's article. The third installment will appear in the September issue of the Journal.

General Derivation of Orifice Meter Flow Formulas

The energy of a fluid at any point in a pipe line can be expressed in feet head of fluid at flowing density, which head is a combination of Head of Position H_e, Pressure Head H_p, and Velocity H_v. The meanings of these heads is illustrated in Fig. 2.

Considering then the flow of any fluid through an orifice in a pipe line and considering a horizontal meter run and no change in density, the derivation of flow formula is as follows: (See Fig. 3)

Derivation of Flow Formula For any Fluid

	I	II
Velocity in Ft./Sec.	v_1	v_2
Pressure Psi Abs. (at Pressure Taps)	P_1	P_2
Density Fluid Lbs/Cu. Ft. ..	w	w
Cross section Area, Sq. Ft.	A_1 (Pipe)	A_2 (Orifice)

$$A_1=\frac{\pi}{4}\left(\frac{d}{12}\right)^2 \qquad A_2=\frac{\pi}{4}\left(\frac{d}{12}\right)^2 \tag{1}$$

Flow Cu. Ft. Sec. $A_1v_1 = A_2v_2$ (2)

$$v_1=\frac{A_2v_2}{A_1}=\left(\frac{d}{D}\right)^2 v_2=\beta^2 v_2 \tag{3}$$

Assuming no loss in energy from I to II and constant density then

$$H_{e1}+H_{p1}+H_{v1}=H_{e2}+H_{p2}+H_{v2} \tag{4}$$

but since $H_{e1} = H_{e2}$ for horizontal run

$$\frac{144P_1}{w}+\frac{v_1^2}{2g}=\frac{144P_2}{w}+\frac{v_2^2}{2g} \tag{5}$$

and substituting for v_1 from (3)

$$\frac{144P_1}{w}+\frac{\beta^4 v_2^2}{2g}=\frac{144P_2}{w}+\frac{v_2^2}{2g} \tag{6}$$

$$\frac{144}{w}(P_1-P_2)=\frac{v_2^2}{2g}(1-\beta^4) \tag{7}$$

and solving for v_2

$$v_2=\sqrt{\frac{144(P_1-P_2)}{w}\times\frac{2g}{(1-\beta^4)}}\ \text{Ft./Sec.} \tag{8}$$

Inserting a test coefficient of discharge (c) to convert theoretical flow to actual flow in the formula $Q_f = A_2v_2$ then

$$Q_{sec}=\frac{c}{\sqrt{1-\beta^4}}\ \frac{\pi}{4}\left(\frac{d}{12}\right)^2\sqrt{\frac{144(P_1-P_2)2g}{w}}\ \text{Cu.Ft./Sec.} \tag{9}$$

The velocity of approach factor $(1/\sqrt{1-\beta^4})$ can be combined with (c) into a coefficient of discharge $E = (c/\sqrt{1-\beta^4})$ and showing the differential pressure in feet of flowing fluid $H=$

$$\left(\frac{144(P_1-P_2)}{w}\right)$$

and multiplying by 3600 the flow formula can be shown as

$$Q_f=\frac{\pi}{4}\frac{d^2}{144}\times\left(\frac{c}{\sqrt{1-\beta^4}}\right)\times\sqrt{2gH}\times 3600=$$

$$19.64\ d^2E\sqrt{2gH}\ \text{Cu.Ft./Hr.} \tag{10}$$

A more useful formula is one expressing differential by (P_1-P_2) and by multiplying equation (9) by 3600, and inserting the value of $g = 32.17$ ft./second^2,

$$Q_f=1890.0\ d^2E\sqrt{\frac{P_1-P_2}{w}}\ \text{Cu.Ft./Hr.} \tag{11}$$

If differential is recorded in inches of water (h) at 60 F. instead of (P_1-P_2), the difference in pressure between the upstream and downstream pressure taps, and the density of water = 62.37 lbs/cu. ft.

1" Water Pressure = $h/12\times62.37/144 = 0.036094$ psi., then (11) becomes

$$Q_f=1890.0\ d^2E\sqrt{\frac{0.036094\,h}{w}}\quad\text{or}$$

$$Q_f=359.1\ d^2E\sqrt{h/w}\ \text{Cu.Ft./Hr.} \tag{12}$$

at flow density or

$$W=359.1\ d^2E\sqrt{hw}\ \text{Lbs. per Hr.} \tag{12}'$$

as $W = Q_f \times w$

For any one set of pressure taps, the coefficient E for any one pipe size has a definite value for any given sized orifice when the value of R (The Reynolds Number at the plane of the orifice) is infinite. This value of E is called K_o. For any other value of R the value of E also has a definite value for this same orifice and pipe; the ratio of this actual value of E to its value K_o being called the Reynolds No. factor (F_R), where $F_R = E/K_o$, therefore,

$$E = K_oF_R \tag{13}$$

and formula (12) becomes equal to

$$Q_f=359.1\ d^2K_oF_R\sqrt{h/w}\ \text{Cu.Ft./Hr.} \tag{14}$$

at flow density.

Notes on K_o

In C.N.G.A. Bulletin TS-353 tables of $Z = 338.2\ K_{o4}$ are given for each 0.001 change in beta where $K_{o4} = K_o$ for a 4.026-in. I.D. pipe. Other tables of (L) values are given for other standard pipe sizes for each 0.01 change in beta. For any one orifice in any one pipe, the values of K_o for Flange Taps are different from those for Pipe Taps. For the same beta ratio in a given pipe and in a 4.026-in. pipe,

$$L=\frac{K_o \text{ for other pipe}}{K_{o4} \text{ for 4.026-in. pipe}} \quad\text{or}$$

$$K_o = LK_{o4} \text{ for other pipe.}$$

September Meeting: Saturday, the 15th, 1951, Rio Hondo Country Club, Downey, Calif. Dinner at 6:30, meeting at 8:00 P.M.

Feature: Low Jinks and Golf Tournament.

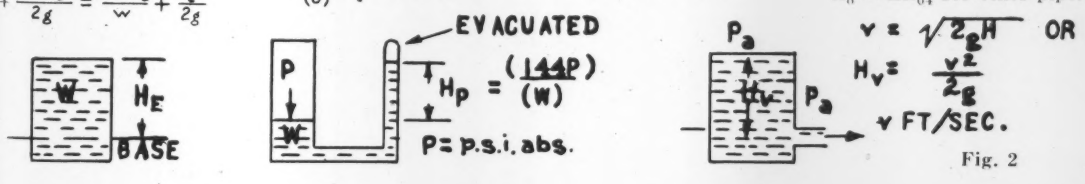

Fig. 2

Flow Equations for Gases

Referring to formula (14) the density of a gas is equal to

$$w = \frac{0.7654\ GPY \times 520}{14.73 \times T}\ \text{Lbs./Cu.Ft.} \qquad (15)$$

Where density of air at 14.73 psi. abs. and 60 F. or 520 deg. abs. = .07654 lbs/cu. ft.

G = Ratio of weight of a cubic foot of gas to a cubic foot of air at 14.73 psi. and 60 F.

T = 460+deg. F. = Flow Temperature.

P in the following formulas will represent some intermediate pressure in the meter run between the upstream and downstream pressure taps, in psi. abs.

Y is the superexpansibility factor for the gas.

Substituting this value of w in equation (14),

$$Q_f = 359.1\ K_o d^2 F_R \sqrt{\frac{14.73\ Th}{0.07654\ GPY \times 520}} \qquad (16)$$

$$\text{or } Q_f = 218.44\ K_o d^2 F_R \sqrt{\frac{hT}{GPY}}\ \text{Cu.Ft./Hr} \qquad (16)'$$

at flowing density.

To convert flow to equivalent cu. ft. at standard condition of 14.73 psi. and 60 F. formula (16) is multiplied by PY/14.73×520/T which becomes

$$Q_{st} = 359.1\ K_o d^2\ F_R \sqrt{\frac{14.73 \times T \times h}{0.07654 \times GPY \times 520}} \times \frac{PY}{14.73} \times \frac{520}{T} \qquad (17)$$

Std. Cu. Ft./Hr at 14.73 psi. & 60 F.

In actual practice the downstream pressure P_2 is usually recorded in place of the intermediate pressure P used above and consequently when P_2 is inserted in (17) a correction factor F_{e2} known as the expansion factor must be applied, which factor varies with beta ratio and ratio of h/P_2. Using P_2 in place of P flow then becomes equal to

$$Q_{st} = (338.2\ K_o d^2) \times F_{e2} \times F_R \times \sqrt{1/G} \times \sqrt{520/T} \times \sqrt{Y} \times \sqrt{hP_2} = \text{Std.Cu.Ft.} \qquad (18)$$

= (Basic Hourly Coef.) × (Exp. Fact.) × (Rey. Fact.) × (Grav. Fact.) × (Temp. Fact.) × (Sup. Exp. Fact.) × (Ext.) = Std. Cu. Ft.

$$= C \times F_{e2} \times F_R \times F_G \times F_T \times F_{Pv} \times \sqrt{hP_2} = \text{Std.Cu.Ft.}$$

$$Q_{st} = C\ F_{e2}\ F_R\ F_G\ F_T\ F_{Pv} \sqrt{hP_2} \qquad (18)'$$

Standard Cu.Ft. at 14.73 psi. abs. and 60 F.

Note: When gases are measured at extremely high pressures or when some type of liquid sealing fluids are used special seal factors are required. See Formula 23.

When liquid seals are used on gas meters an additional seal factor F_M, which equals $\sqrt{1-G_S/13.57}$, must be applied to the general flow formula, where G_S is the specific gravity of the sealing liquid referred to a base of water at 60 F.=1.0000.

When no liquid sealing is used in the measurement of gases over 500 psi. gage, the density of gas compared to the density of mercury becomes appreciable. Let G = the specific gravity of the gas compared to air = 1.0000 as previously defined and let G_S = ratio of the weight of one cubic foot of gas at flowing pressure and instrument temperature to the weight of one cubic foot of water at 60 F. The additional factor F_M as shown by formula (23) should be used in the measurements of gases at pressures over 500 psi. gage.

$$W = (359.1\ d^2 K_o)\ F_R (\sqrt{h/w})_w = 359.1\ d^2 K_o F_R \sqrt{hw}$$

$$W = (359.1\ d^2 K_o) F_R \sqrt{h \times 62.37 \times G_{60} T_c}$$

$$W = 2836.\ d^2 K_o\ F_R \sqrt{h G_{60} T_c}\ \text{Lbs./Hr.} \qquad (22)$$

In the above formulas 20, 21, 22, (h) is the actual differential pressure across the pressure taps. Bellows types of differential recorders, record this true differential pressure (h) when the bellows and gage lines are filled with the commodity being measured. When other liquids are used for sealing, the seal pots must be of large size to avoid the necessity of applying a seal pot correction factor.

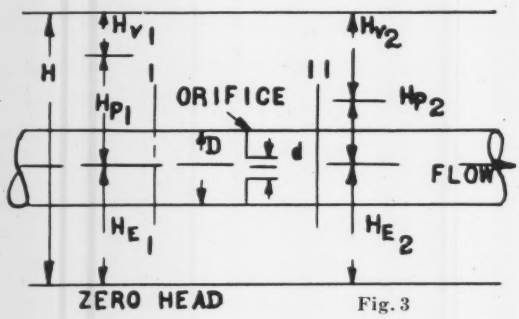

Fig. 3

A simplified formula for the computation of this value of F_M for gases is shown below.

$$G_S = \left(\frac{0.07654 \times GPY \times 520}{14.73\ T \times 62.37}\right) = \left(0.04332 \frac{GPY}{T}\right)$$

$$\text{and } F_M = \sqrt{1 - 0.003195 \frac{GPY}{T}}$$

Example for P=715# G=0.7 and Y =1.17 and T=520 F. abs., F_M=0.9982

Flow Equations for Liquids

Let G_{60}=Spec. gravity of liquid at 60 F., which equals the ratio of its density at 60 F. to weight of an equal volume of water at 60 F.

Let G_f = Spec. gravity of liquid at flowing temperature conditions which equals the ratio of its density at flowing temperature to the density of an equal volume of water at 60 F.

Actual density of a liquid at flowing temperature in lbs./cu.ft. equals $w = 62.37 \times G_f$ or $w = 62.37\ G_{60} T_c$ (19)

$$\text{where } T_c = \frac{G_f}{G_{60}} = \frac{w}{w_{60}}$$

The value of T_c is available for most all common liquids in published tables.

Substituting the value of $w = 62.37\ G_{60} T_c$ and multiplying by 7.481, the number of gals. per cu. ft., equation for liquid flow becomes

$$Q_f = 359.1\ d^2 K_o \times F_R \sqrt{\frac{h}{62.37 G_{60} T_c}} \times 7.481$$

$$Q_f = (340.1\ d^2 K_o) F_R \sqrt{\frac{1}{G_{60}}} \times \sqrt{\frac{1}{T_c}}\ \sqrt{h} \qquad (20)$$

Gals. per hour at flow density.

Ordinarily flow is desired in equivalent gals. at 60 F. which can be obtained by multiplying formula (20) by T_c or,

$$Q_{60} = (340.1\ d^2 K_o) F_R \sqrt{\frac{1}{G_{60}}}\ \sqrt{T_c}\ \sqrt{h} \qquad (21)$$

Gals. per hour at 60 F.

If flow is desired in lbs./hr.=Q_f $G_{60} T_c \times 62.37 = Q_f w$

It is to be noted that in the above formulas, liquids are assumed to be non-compressible. At high pressures some liquids are somewhat compressible but for most ordinary measurements such a correction can be disregarded.

When mercury types of differential recording gages are used, however, the recorded differential does not equal the actual differential across the pressure taps because of the appreciable density of the sealing liquid compared to the density of mercury referring to Fig. 4 the correction factor required is determined as follows:

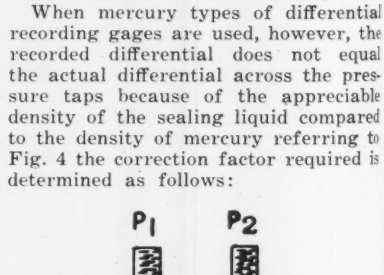

Fig. 4

Nomenclature:

P_1=upstream pressure in inches mercury

P_2=downstream pressure in inches mercury

a=head of mercury which equals inches head of mercury movement in the recording gage or manometer

G_s=Specific gravity of sealing fluid compared to water of 60 F.=1.0000

G_m=Specific gravity of mercury compared to water at 60 F.=1.0000

True differential pressure in inches of water=$h=G_m(P_1-P_2)$

Recorded differential pressure in inches of water=$h'=G_m a$

Referring to Fig. 4 expressing pressures in inches of mercury

$P_1 = a(G_s/G_m) = P_2 + a$

$P_1 - P_2 = a - a(G_s/G_m) = a(1 - G_s/G_m)$

Converting pressures to inches of water by multiplying by G_m

$G_m(P_1 - P_2) = G_m a(1 - G_s/G_m)$

or $h = h'(1 - G_s/G_m)$

In orifice meter flow calculations, it is necessary to solve for $\sqrt{h}$. The above formula for h can then be rewritten as:

$\sqrt{h} = \sqrt{h'}\sqrt{1 - G_s/G_m}$ and since h' is the recorded differential when mercury type differential gages are used, an additional correction factor F_M commonly called the seal factor, is required when mercury differential gages are used, where

$$F_M = \sqrt{1 - G_s/G_m} \text{ and } \sqrt{h} = F_M\sqrt{h'} \qquad (23)$$

In formula (23) it is assumed that seal pots are of large enough sizes so that the sealing liquid levels in each seal pot remain practically unchanged between zero to maximum flow rates. (See special F_M formulas when this is not the case). In the above equations G_s and G_m are the specific gravities of the sealing liquid and mercury at gage temperature. Usually gage temperature is assumed as being at 60 F. and the error involved by this assumption is ordinarily small. G_m at 60 F. equals 13.57. For a gage at 100 F. for example, the maximum possible error caused by this assumption is about 0.1 percent, the degree of error varying with the type of liquid over the mercury. When no specific sealing liquid is used, the metered liquid is the sealing liquid.

Formulas (20), (21), and (22) can then be written for liquid flow using mercury type differential recorders as follows:

$$Q_f = (340.1\ d^2\ K_o)F_R F_M\sqrt{1/G_{60}} \times \sqrt{1/T_c} \times \sqrt{h'} \text{ Gals./Hr. at flow density} \qquad (20)'$$

$$Q = (340.1\ d^2\ K_o)F_R F_M\sqrt{1/G_{60}} \times \sqrt{T_c} \times \sqrt{h'} \text{ Gals./Hr. at 60 F.} \qquad (21)'$$

$$\text{or } Q = C_L \times F_R F_M \times L_G \times L_T\sqrt{h'} \text{ Gals./Hr. at 60 F.} \qquad (21)''$$

$$W = (2836.d^2K_o)F_R F_M \times \sqrt{h'G_{60}T_c} \text{ Lbs./Hr.} \qquad (22)'$$

For liquids, values of $(340.1K_0d^2)$ and $(2836.K_0d^2)$ can be obtained from published tables for gases of $C = 338.2$ K_0d^2 by multiplying these published values of $C = 338.2K_0d^2$ for gases, by (340.1/338.2) and (2836./338.2).

If G_f, the actual flowing specific gravity is known

In formulas (20) and (20)', $\sqrt{1/G_f}$ can be used in place of $\sqrt{1/(G_{60} \times T_c)}$

In formulas (21) and (21)', $T_c\sqrt{1/G_f}$ can be used in place of $\sqrt{T_c/G_{60}}$

In formulas (22) and (22)', $\sqrt{G_f}$ can be used in place of $\sqrt{G_{60}T_c}$

Data sheets showing values of $\sqrt{1/G_{60}}$, $\sqrt{1 - G_s/G_m}$, and $\sqrt{T_c}$ can be obtained for a number of petroleum products and for water from the S.C.M.A.

Reynold's Number Factor F_R

The factor F_R for liquids varies with (R), the Reynolds Number at the plane of the orifice as well as with beta and the type of pressure taps used. For high (R) values it also varies with the size of pipe.

Approximate flange tap values of F_R are given in the following table for values of R from 100 to 100,000 for various beta values. This data was obtained from the chart given by the Pittsburgh Equitable Meter Company in their book "The Orifice Meter." This data assumes that the F_R value will be the same for any one set of R and beta conditions regardless of pipe size.

R	APPROXIMATE VALUES OF REYNOLDS NO. FACTOR F_R (FLANGE TAPS) FOR VALUES OF (R)													
β	100	200	400	600	800	1000	2000	3000	4000	6000	10000	20000	50000	1000000
.2	1.150	1.157	1.148	1.135	1.120	1.102	1.072	1.059	1.052	1.043	1.036	1.026	1.017	1.008
.3	1.152	1.165	1.155	1.140	1.124	1.110	1.077	1.062	1.055	1.045	1.037	1.026	1.017	1.008
.4	1.154	1.174	1.165	1.153	1.138	1.125	1.095	1.080	1.070	1.056	1.045	1.030	1.017	1.008
.5	1.160	1.195	1.198	1.187	1.175	1.161	1.122	1.100	1.087	1.070	1.052	1.036	1.017	1.008
.55	1.175	1.213	1.223	1.213	1.200	1.190	1.148	1.122	1.100	1.080	1.055	1.036	1.017	1.008
.6	1.196	1.240	1.252	1.247	1.237	1.226	1.177	1.143	1.118	1.090	1.060	1.037	1.017	1.008

R, the Reynold's Number at the plane of orifice can be computed by the following formula where,

d = Orifice diameter in inches

Q_f = Gals/hour at flow temperature

Q_{60} = Gals/hour corrected to 60 F.

G_f = Specific gravity at flowing temp. (compared to water at 60 F.)

G_{60} = Specific gravity at 60 F. (compared to water at 60 F.)

T_c = Volumetric temperature correction $= G_f/G_{60}$

Note:

$Q_f = Q_{60}/T_c$ and $G_f = G_{60}T_c$ and

$Q_fG_f = Q_{60}/T_c \times G_{60}T_c = Q_{60}G_{60}$

If u = absolute viscosity at flowing temperature

$$R = \frac{0.5266Q_fG_f}{du} = \frac{0.5266Q_{60}G_{60}}{du} \qquad (24)$$

If u = absolute viscosity in centipoises at flowing temperature

$$R = \frac{52.66Q_fG_f}{du} = \frac{52.66Q_{60}G_{60}}{du} \qquad (24)'$$

An alignment chart for determining R is given on S.C.M.A. data sheet No. 242.

On S.C.M.A. data sheet No. 175, the Foxboro Company's curve data for obtaining F_R values is shown which data covers a flow range of R values from about 100 to 10,000 for various beta ratios. On this curve F_R values are plotted against a ratio $= Q'_f/dt_s$, F_R data given covers a range of Q'_f/dt_s between 0.35 to 40.00, where

$t_s = 465.u/G_f$ where

u = abs. viscosity in poises at flow temp.

d = orifice diam. in inches

G_f = specific gravity at flow temp.

Q'_f = indicated gal./hr. at flow temp. uncorrected for F_R

Q'_{60} = ind. gal/hr. at 60 F. uncorrected for F_R

$$\frac{Q'_f}{dt_s} \text{ also} = \frac{Q'_fG_f}{465du} = \frac{Q'_{60}G_{60}}{465du} \text{ and}$$

$$R = 245.F_R \times \frac{Q'_f}{dt_s},$$

since from equation (24)

$$R = \frac{0.5266Q_fG_f}{du} = (\text{Factor})\frac{Q'_fG_f}{465du} \text{ or}$$

$$(\text{Factor}) = 245.\frac{Q_f}{Q'_f} = 245 \times \frac{Q'_fF_R}{Q'_f} = (245.F_R)$$

F_R values for R values greater than those shown in the above F_R table or those covered in the Foxboro data can be calculated from the formula given in the C.N.G.A. Bulletin TS-353 given as follows:

$$F_R = 1 + \frac{(J+B)d}{R}$$

Values of (J+B)d versus beta are given for various pipe sizes and for both flange taps and pipe taps on S.C.M.A. data sheets 175A and 175B.

d = orifice diam. in inches and D = pipe diam. in inches and $\beta = d/D$

$J = 830. - 5000.\beta + 9000\beta^2 - 4200\beta^3$ for Flange and Pipe Taps

$B = 530/\sqrt{D}$ for Flange Taps

$B = 75 + (875/D)$ for Pipe Taps

R = Reynold's No. at plane of orifice $= vdw/12u$, where

v = actual velocity of fluid jet at the plane of the orifice, ft. per sec.

d = orifice diameter in inches

w = density of fluid at orifice, lbs. per cu. ft.

u = viscosity of flowing fluid, lbs. per sec. ft.

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Manufacturers' New Literature

In this department we report new literature pertaining to Instrumentation, received from the manufacturers. We urge readers to request ONLY those bulletins which will be of value to them. Use the Postage-free Order Card on Page 989.

Requests for literature FROM ABROAD should be made on company letterhead and mailed DIRECTLY to the manufacturers.

Temperature

T-551 **Pyrometers.** 4-page bulletin illustrates and describes maker's "Xactemp" self-contained portable pyrometers with various thermocouple tips. —Claude S. Gordon Co., 3000 South Wallace St., Chicago 16, Ill.

T-552 **Pyrometers.** 12-page illustrated Catalog GEC-713 describes maker's line of "Type HP" indicating and controlling pyrometers. Includes principles and accessories.—Apparatus Dep't., General Electric Company, Schenectady, N. Y.

T-553 **Temperature Regulators.** 2-page Bulletin A.I.A. File No. 30-C-3 illustrates and describes maker's "Series 1100" temperature regulator for use from 80 to 250 degrees F.—Hoffman Specialty Company, 1001 York St., Indianapolis 7, Ind.

T-554 **Thermometers and Pressure Gages.** 8-page catalog Form No. G-143-B illustrates and describes maker's line of recording thermometers, dial-indicating thermometers, recording gages for pressure and vacuum, and accessories.—Instrument and Gauge Div., The Electric Auto-Lite Co., Toledo 1, Ohio.

T-555 **Thermocouple Data.** 8.5 x 5.5 in. card has chart showing applications, calibration symbols, conductors, polarity, and color codes of thermocouples and extension wire. Resistance table for pyrometer wires on reverse side.—Thermo Electric Co., Inc., Fair Lawn, N. J.

T-556 **Thermocouples.** 20-page illustrated Catalog GEC-714 describes maker's line of thermocouples, components, and accessories. Includes factors for choice of element and prices.—Apparatus Dep't., General Electric Company, Schenectady, N. Y.

T-557 **Temperature-conversion Chart.** 2-page chart on plasticized board converts temperatures from −70 to +650 degrees to either Fahrenheit or Centigrade. Reverse side lists maker's thermostats.—Stevens Manufacturing Co., Inc., 69 S. Walnut St., Mansfield, Ohio.

T-558 **Bimetal Thermostats.** 2-page Bulletin L-4079 illustrates and describes maker's "Type W" bimetal thermostats. Includes principle, construction, and styles.—Stevens Manufacturing Co., Inc., 69 S. Walnut St., Mansfield, Ohio.

T-559 **Temperature and Humidity Control.** 4-page Bulletin K-151 illustrates and describes "Kathabar" system for temperature and humidity control for laboratory and industrial atmospheres.—Surface Combustion Corp., Toledo 1, Ohio.

T-560 **Dehumidifier.** 4-page Bulletin DD-130 illustrates and describes maker's dehumidifier for instrument air, which uses Sovabead desiccant, and other products.—Industrol Corp., 427 Westfield Ave., East, Roselle Park, N. J.

T-561 **Refrigeration Equipment.** 4-page bulletin illustrates and describes "Hudson Bay" refrigeration equipment —utility cabinets, shell freezer, and temperature-humidity cabinets.—Refrigeration Systems, Inc., 646 W. Washington Blvd., Chicago 6, Ill.

Pressure

T-562 **Insulated Panels.** 2-page Bulletin WR-251 describes maker's prefabricated insulated panels for erection of hot or cold walk-in rooms.—Bowser Technical Refrigeration, Division Bowser Inc., Terryville, Conn.

T-563 **Manometers and Flowmeters.** 44-page Condensed Catalog C-12 illustrates and describes maker's line of manometers, inclinometers, draft gages, level gages, sight feed bubblers, and accessories.—The Meriam Instrument Co., 10958 Madison Ave., Cleveland 2, Ohio.

T-564 **Vacuum Gage.** 20-page No. 51-6-43 issue of house organ "Announcer" features description of "Hastings Vacuum Gauge," centrifuges, polarimeter, ultrasonic generator, and other laboratory equipment.—Burrell Corporation, 2223 Fifth Ave., Pittsburgh 19, Penna.

T-565 **Draft and Low-pressure Instruments.** 20-page Bulletin 51-667 illustrates and describes maker's line of draft and low-pressure instruments. Includes indicators, recorders, controllers, and principles of operation.—The Hays Corporation, Michigan City, Ind.

Flow

T-566 **Multipump Controllers.** 4-page Bulletin 1510 illustrates and describes "Duotrols" for automatic control of 2 or more pumps in pressure-tank systems.—Automatic Control Co., St. Paul 4, Minn.

T-567 **Fuel-flow Transmitter.** 8-page Bulletin 200 illustrates and describes maker's volumetric fuel-flow transmitter and summator.—Revere Corporation of America, Wallingford, Conn.

Combustion

T-568 **Smoke Indicators.** 6-page Bulletin CM506 illustrates and describes

how "Fireye" equipment detects, indicates and records smoke conditions. Includes specifications of maker's line. —Combustion Control Corp., 77 Broadway, Cambridge 42, Mass.

T-569 **Combustion Control.** 4-page Bulletin 604 illustrates and describes maker's line of electronic and photoelectric equipment for protection against failure of oil or gas flame.—Combustion Control Corp., 77 Broadway, Cambridge 42, Mass.

T-570 **Fire Detector.** 6-page folder illustrates and describes "Fireye" detector which detects fire and discriminates against other illumination.—Fireye Corp., 77 Broadway, Cambridge 42, Mass.

T-571 **Boiler-plant Design.** 14-page Vol. 9 No. 3 issue of house organ "Fuelomizer" features articles on boiler-plant design, smoke control, and description of combustion instruments.—Jno. D. Hiles Co., Inc., Plaza Bldg., Pittsburgh, Penna.

Optical

T-572 **Polarizers.** 6-page No. 2 issue of house organ "Polaroid Reporter" has articles on polarizing lenses for goggles, modern polarizers, and a new monochromator.—Polaroid Corporation, Dep't. PR-2, Cambridge 39, Mass.

T-573 **Photogrammetric Instruments.** 16-page catalog illustrates and describes maker's line of precision photogrammetric instruments—stereoscopes, contour finders, height finder, survey cameras, etc.—Abrams Instrument Corp., 600-620 E. Shiawassee St., Lansing 1, Mich.

T-574 **Metallograph.** 20-page Catalog E-232 illustrates and describes maker's "Balphot" metallograph for rapid determination of crystalline structure, grain size, and composition of metals.—Bausch & Lomb Optical Co., Rochester 2, N. Y.

T-575 **Metallograph.** 4-page Bulletin 5-451 illustrates and describes maker's "OPL" compact metallograph. Includes typical microphotographs.—F. T. Griswold Mfg. Co., 305 W. Lancaster Ave., Wayne, Penna.

Chemical Laboratory

T-576 **Mass Spectrometer.** 12-page Vol. 5 No. 2 issue of house organ "CEC Recordings" features articles on design of mass spectrometer, bibliography of mass-spectrometer articles, and other articles.—Consolidated Engineering Corp., 300 N. Sierra Madre Villa, Pasadena 8, Calif.

T-577 **Spectrographic Analyses of Copper Alloys.** 12-page lithoprint reports on a technique for spectrographic analyses of copper alloys using maker's "Quantometer."—Applied Research Laboratories, 4336 San Fernando Rd., Glendale 4, Calif.

T-578 **Spectrographic Analyses of Tool Steels.** 13-page lithoprint gives technique for a spectrographic analysis of high-speed tool steels, using point-to-plane sparking and "Production Control Quantometer."—Applied Research Laboratories, 4336 San Fernando Rd., Glendale 4, Calif.

T-579 **Production Spectrograph.** 8-page brochure illustrates and describes "Quantometer" spectrochemical-recorder for rapid spectrochemical analyses of metals and nonmetals.—Applied Re-

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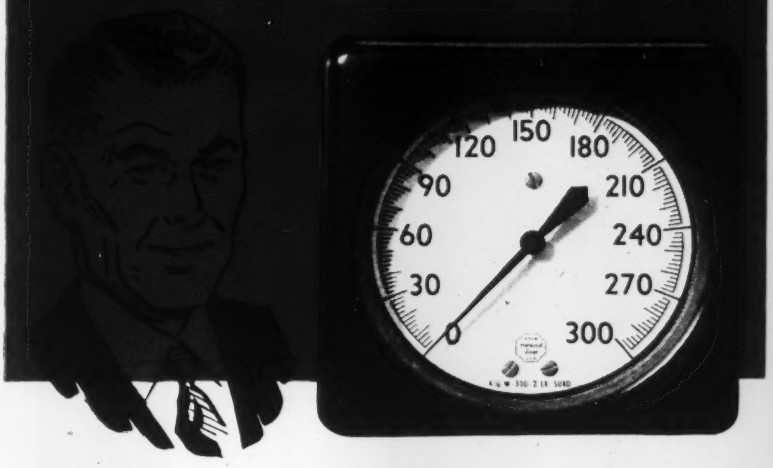

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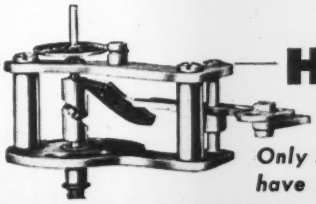

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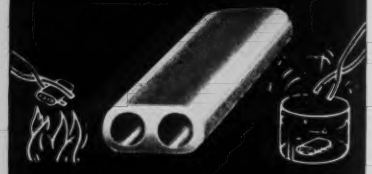

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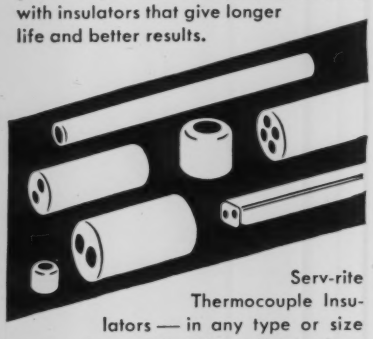

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NEW LITERATURE

search Laboratories, 4336 San Fernando Rd., Glendale 4, Calif.

T-580 **Chemical Oscillometry.** 30-page issue Vol. 4 of house organ "Scientific Apparatus and Methods" features article on "Chemical Oscillometry." Includes catalog of maker's line of laboratory equipment.—E. H. Sargent and Co., 4647 W. Foster Ave., Chicago 30, Ill.

T-581 **pH Instrumentation.** 17-page Reprint R-36 titled "The Development of pH Instrumentation" describes the physical and chemical principles of pH instrumentation, including the origin of the pH scale, electrodes, and meters.—Beckman Instruments, Inc., 1130 Mission St., South Pasadena, Calif.

T-582 **Chemical Spectroscopy.** 52-page illustrated booklet contains reprint of paper "Chemical Spectroscopy" by Dr. W. R. Brode. Includes spectroscopic methods of analysis and use of emission and absorption spectra. Cost is $1.35.—American Society for Testing Materials, 1916 Race St., Philadelphia 3, Penna.

T-583 **Spectrographic Analyses of Brass.** 8-page booklet "Control—the Key to Improvement in Quality Products" illustrates and describes the first industrial application of direct-reading spectrograph in metallurgical control of brass.—Titan Metal Manufacturing Co., Bellefonte, Penna.

T-584 **Spectrochemistry.** 6-page folder Bulletin 225-139 titled "Spectrochemistry—a long title for a short story" illustrates and describes the basic principle of spectrochemistry and maker's spectrophotometers.—Coleman Instruments, Inc., 318 Madison St., Maywood, Ill.

T-585 **X-ray Spectrometer.** 4-page Instrumentation Data Sheet No. 10.16-1 describes principles and design features of the "Norelco Geiger-Counter X-Ray Spectrometer," including diffraction unit, goniometer, and recorder.—Industrial Div., Minneapolis-Honeywell Regulator Co., Philadelphia 44, Penna.

T-586 **Raman Spectroscopy.** 18-page booklet "Raman Spectroscopy" illustrates and describes the physical principles and equipment requirements for spectrochemical analysis by Raman technique.—Applied Research Laboratories, 4336 San Fernando Rd., Glendale 4, Calif.

T-587 **Laboratory Equipment.** 21-page catalog "Modern Equipment for the Water & Sewage Laboratory" describes maker's line of analysis equipment.—E. Machlett & Son, 220 E. 23rd St., New York 10, N. Y.

T-588 **Analytical Instruments.** 12-page brochure describes facilities for design and manufacture of analytical instruments—mass spectrometer, leak detector, "Titrilog," "Gamatek," etc.—Consolidated Engineering Corp., 300 N. Sierra Madre Villa, Pasadena, Calif.

T-589 **Oxygen Analyzer.** 2-page Bulletins 202 and DGE 350 illustrate and describe principles, maintenance factors, corrections, and specifications of maker's "Model D" oxygen analyzer.—Arnold O. Beckman, Inc., 1020 Mission St., South Pasadena, Calif.

T-590 **Aluminum Research.** 14-page illustrated booklet describes new re-

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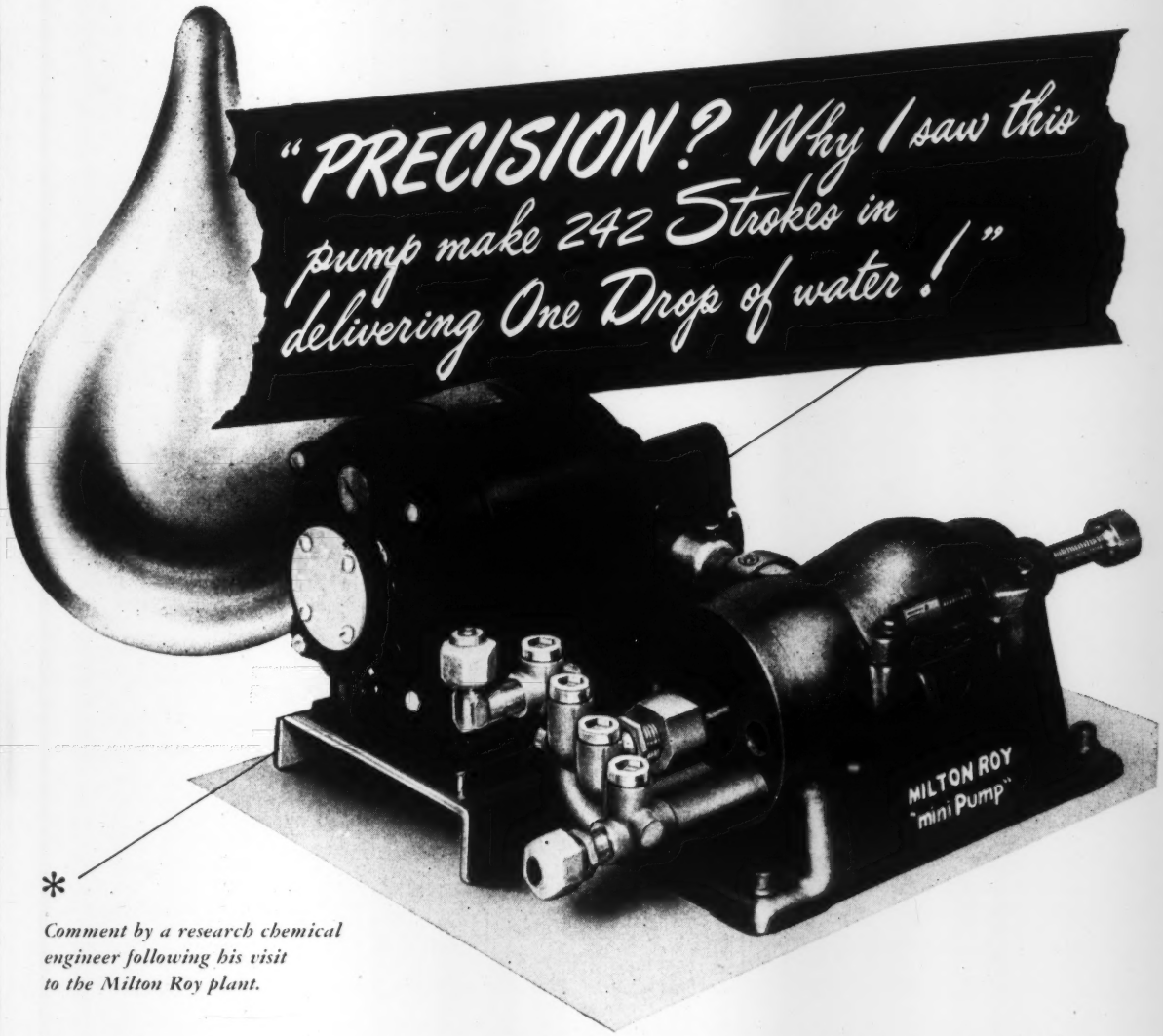

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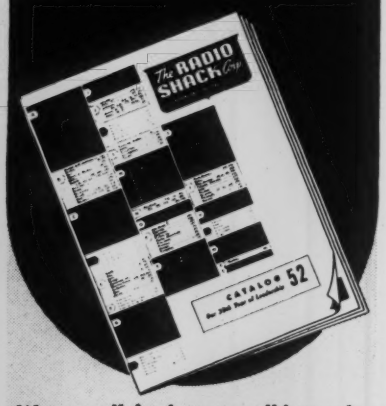

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NEW LITERATURE

search laboratory and scope of research. —Aluminum Company of America, 680 Gulf Bldg., Pittsburgh 19, Penna.

Chemical Process

T-591 **pH and Conductivity.** 44-page Catalog 15-12 illustrates and describes fundamental principles of electrometric measurements—pH, oxidation-reduction, and conductivity. Includes typical systems.—Brown Instruments Division, Minneapolis-Honeywell Regulator Co., Wayne and Roberts Ave., Philadelphia 44, Penna.

T-592 **Process Control.** 40-page Vol. 5 No. 3 issue of house organ "Electronic Pneumatic Mechanical Instrumentation" features articles on "Spotlighting Process Control," "New Flow Transmitter," and others.—Industrial Division, Minneapolis-Honeywell Regulator Co., Wayne and Windrim Aves., Philadelphia 44, Penna.

T-593 **Gas Purification.** 20-page Vol. 10 No. 2 issue of house organ "The Flow Line" features articles on the Girbotol process for gas purification, new Richfield pipe line, and others.—Rockwell Manufacturing Co., 400 N. Lexington Ave., Pittsburgh 8, Penna.

T-594 **Chloromycetin.** 20-page Vol. 10 No. 3 issue of house organ "The Flow Line" features articles on processes for manufacture of chloromycetin and ethylene; also the catalytic polymerization process.—Rockwell Manufacturing Co., 400 N. Lexington Ave., Pittsburgh 8, Penna.

T-595 **Water Supply,** Vol. XXXV, No. 2 issue of house organ "Water Journal" features articles on stream pollution, ground-water supply of Houston, Texas, and the economics of water-meter repairs.—Rockwell Manufacturing Co., 400 N. Lexington Ave., Pittsburgh 8, Penna.

T-596 **Corrosion in Water Systems.** 8-page Vol. 20 No. 7 issue of "The Betz Indicator" features article "Chemicals used in Cooling Water Treatment," which tells how corrosion is minimized in water systems.—W. H. and L. D. Betz, Gillingham & Worth Sts., Philadelphia 24, Penna.

Electrical and Electronic Instruments

T-597 **V-h-f. Frequency Meter.** 4-page bulletin describes development and operation of a v-h-f. frequency meter for 20-40 Mc., which has direct-reading scale.—Gertsch Products, Inc., 11846-48 Mississippi Ave., Los Angeles 25, Calif.

T-598 **High-impedance Preamplifier.** 4-page bulletin describes "Model 102 Phantom Repeater," an amplifier with gains of 1, 10, and 100, and input impedance of 200 megohms; for use with test instruments.—Keithley Instruments, 1508 Crawford Rd., Cleveland 6, Ohio.

T-599 **Oscillograph.** 8-page bulletin illustrates and describes maker's high-speed high-sensitivity d-c. and a-c. oscillograph with chopper-type amplifier. —Offner Electronics, Inc., 5320 North Kedzie Ave., Chicago 25, Ill.

T-600 **Recording Potentiometer.** 2-page Instrumentation Data Sheet 10.0-7 illustrates and describes "Electronik" recorder which features 1-second pen

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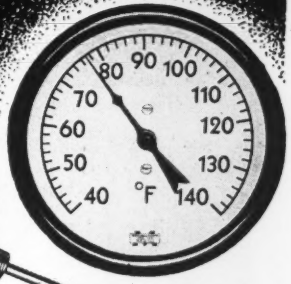

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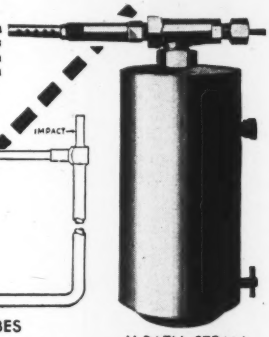

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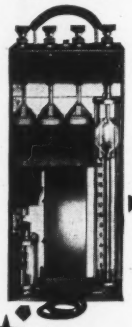

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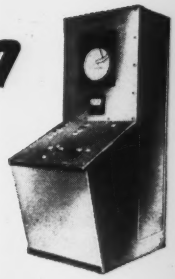

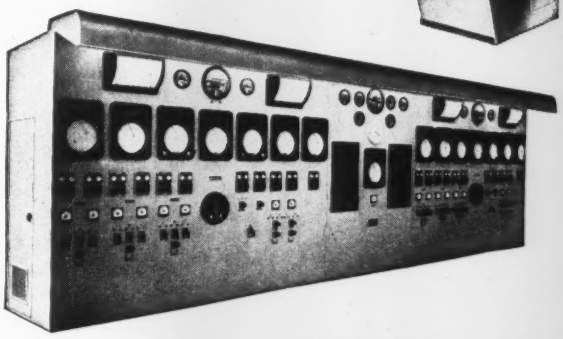

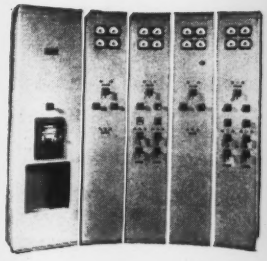

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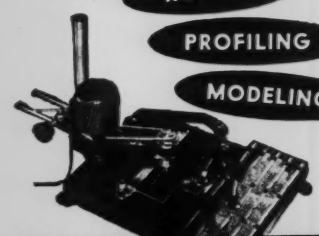

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NEW LITERATURE

speed.—Station 40, Industrial Division, Minneapolis-Honeywell Regulator Co., Philadelphia 44, Penna.

T-601 **Volt-ohm-milliammeter.** 4-page Vol. 18 No. 5 issue of house organ "Electrical Measurements" illustrates and describes self-checking precision laboratory-standard volt-ohm-milliammeter with accuracy of 0.05 percent.—Sensitive Research Instrument Corp., 9-11 Elm Ave., Mt. Vernon, N. Y.

T-602 **Megger.** 8-page Bulletin 21-85 illustrates and describes maker's "Midget Megger" insulation tester, "CVM" constant-voltage megger, and "Midget Megger" ohmmeter.—James G. Biddle Co., 1316 Arch St., Philadelphia 7, Penna.

T-603 **Graphic Recorder.** 4-page Bulletin No. 651 issue of house organ "The Graphic" features article on use of maker's recorder in modern Diesel-electric locomotives for measuring current.—The Esterline-Angus Company, Inc., P. O. Box 596, Indianapolis 6, Ind.

T-604 **Running-time Recorders.** 8-page Bulletin OP1504 illustrates and describes maker's line of running-time recorders which record operating and "time-off" periods of equipment.—The Bristol Company, Waterbury 20, Conn.

T-605 **Electronic Servomechanism.** 1-page Bulletin H-26 illstrates and describes maker's "MOTRON" packaged continuous-balance servocontrol system for automatic positioning, etc.—W. C. Robinette Co., 802 Fair Oaks Ave., South Pasadena, Calif.

T-606 **Relay Test-set.** 2-page bulletin describes single-phase test-set for testing power-system relays and polyphase relays, including impedance relays, current-balance relays, etc.—Arthur E. Booth Co., 4124 Beverly Blvd., Los Angeles 4, Calif.

T-607 **Automatic Data Analyzer.** 3-page brochure illustrates and describes principles of operation of data analyzer which converts coded photographic recordings into interpreted information.—Douglas Aircraft Co., Inc., 3000 Ocean Park Blvd., Santa Monica, Calif.

T-608 **Computer Data Preparer.** 3-page brochure illustrates and describes principle of operation of "Iconolog" machines which translate photographic records into punched cards or typewritten data for computers.—Genisco, 2233 Federal Ave., Los Angeles 64, Calif.

T-609 **Tachometer Indicator.** 2-page Technical Data Sheet No. 42P illustrates and describes features and applications of maker's three-range single-head fixed-type tachometer indicator Series 42P.—Metron Instrument Co., 432 Lincoln St., Denver 9, Colo.

T-610 **Dosimeter.** 2-page Bulletin 106 illustrates and describes maker's (1) self-indicating pocket instrument for measuring total gamma or X-radiation, and (2) charging unit.—Arnold O. Beckman, Inc., 1020 Mission St., South Pasadena, Calif.

T-611 **TV Trouble-Shooting.** 16-page Vol. 16 No. 6 issue of house organ "The CD Capacitor" features article "Emergency TV Trouble Shooting With Common Test Instruments."—Cornell Dubilier Electric Corp., Hamilton Blvd., South Plainfield, N. J.

T-612 **Radio-phonograph Servicing.**

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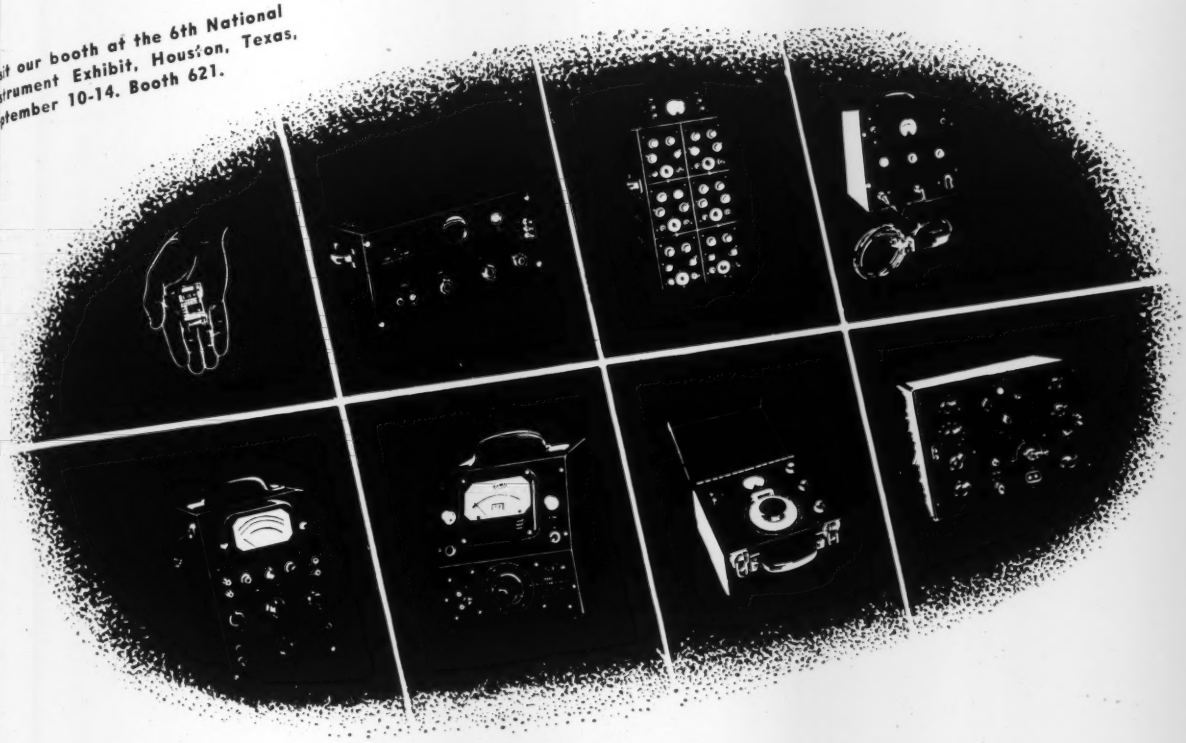

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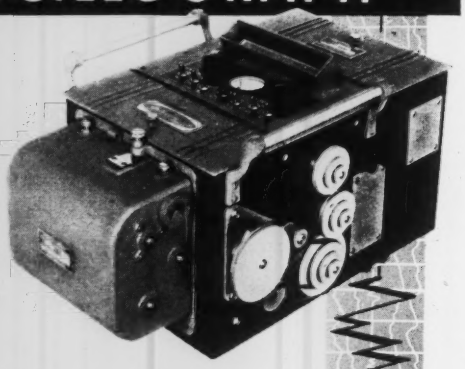

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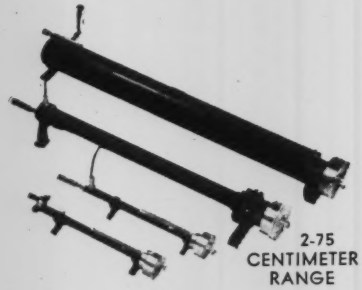

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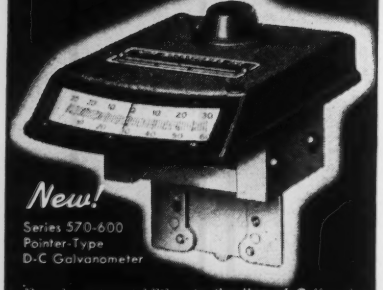

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104-page booklet "Service Hints," volume 4, has hundreds of hints contributed by servicemen on various makes of radios and phonographs. Hints are applicable to electronic circuitry of any type.—Radio Tube Div., Sylvania Electric Products, Inc., Emporium, Penna.

T-613 **Electronics in Defense.** 8-page booklet "Electronics in the Public Interest" emphasizes importance of electronics in defense.—Electronics Dep't., General Electric, Electronics Park, Syracuse, N. Y.

T-614 **Measurements Laboratory.** 16-page Brochure GED-1406 titled "Dedicated to the Future" illustrates and describes facilities and work of new $2,000,000 Measurements Laboratory.—General Electric Company, Schenectady 5, N. Y.

Electrical and Electronic Components

T-615 **Resistors.** 11-page Catalog 14-R illustrates and describes maker's line of precision noninductive fixed wire-wound resistors. Includes data on windings, tolerances, impregnation treatment, etc.—Cinema Engineering Co., 1510 West Verdugo Ave., Burbank, Calif.

T-616 **Resistors.** 2-page May-June issue of house organ "The Ohmite News" features article on "Recordak Duplex Microfilmer" and description of maker's tap switches and special resistors.—Ohmite Manufacturing Co., 4835-41 Flournoy St., Chicago 44, Ill.

T-617 **Metallized Paper Capacitors.** 14-page Vol. 16 No. 5 issue of house organ "The CD Capacitor" features Part II description of metallized paper capacitors.—Cornell-Dubilier Electric Corp., Hamilton Blvd., South Plainfield, N. J.

T-618 **Transformers.** 18-page mid-year catalog describes 441 transformers and related components for electronic applications. All components are indexed.—Standard Transformer Corporation, 3850 Elston Ave., Chicago 18, Ill.

T-619 **Receiving Tubes.** 322-page Manual RC-16 describes types, characteristics, applications, tests, circuits, and outlines of maker's line of receiving tubes—over 460 tubes and kinescopes. Price 50c.—Commercial Engineering, RCA, Harrison, N. J.

T-620 **Tube Substitution.** 40-page "Tube Substitution Manual" has tube-classification chart, circuit modifications requiring resistors, substitution charts for various tube types, and frequently-needed change-over diagrams.—Sylvania Electric Products, Inc., Emporium, Penna.

T-621 **Vacuum-tube Plate Dissipation.** 6-page Application Note AN-150 describes method for measurement of plate dissipation of TV horizontal-deflection output tube.—Tube Dep't., Radio Corporation of America, Harrison, N. J.

T-622 **Oscillator Triode.** 2-page data sheet gives specifications and characteristics of RCA-6026 subminiature oscillator triode for radiosonde service at 400 Mc.—Tube Dep't., Radio Corporation of America, Harrison, N. J.

T-623 **TV Components.** Data sheets describe (1) RCA-227T1 horizontal-de-

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T-624 **TV Replacement Guide.** 26-page "Catalog and Replacement Guide" lists 1500 TV models and chassis and gives maker's replacement component. Separate section lists all "Stancor" TV transformers.—Standard Transformer Corp., 3580 Elston Ave., Chicago 18, Ill.

T-625 **Kinescopes.** 10-page catalog describes specifications, adjustments, ratings, and operating conditions of maker's line of "Teletron" picture tubes.—Cathode-ray Tube Div., Allen B. DuMont Laboratories, Inc., Shafto St. and Bloomfield Ave., Clifton, N. J.

T-626 **Oscillograph Tube.** 2-page Data Sheet 12SP7-5-51 gives specifications and characteristics of RCA-12SP7 12-inch magnetic focus and magnetic-deflection tube for oscillograph or radar service.—Tube Dep't., Radio Corporation of America, Harrison, N. J.

T-627 **Voltage Control.** 4-page bulletin, Form No. 5503, illustrates and describes maker's line of "Powerstat" variable transformers, "Stabiline" voltage regulators and "Varicell" d-c. supplies.—The Superior Electric Co., Bristol, Conn.

T-628 **Transducer.** 20-page booklet describes principles of operation, design considerations, applications, and licensing program for "Vibrotron" transducer, which uses a wire vibrating in a magnetic field.—Institute of Inventive Research, San Antonio, Texas.

T-629 **Silver-zinc Storage Cells.** 4-page Technical Brochures Nos. 1 and 2 describe maker's line of the world's smallest storage cells—the "Silvercel"—which uses silver and zinc.—Yardney Electric Corp., 105-107 Chambers St., New York 7, N. Y.

T-630 **Long-life Storage Battery.** 12-page Vol. 8 No. 3 issue of house organ "Aminco Laboratory News" features short articles on new lead-calcium storage battery, photographic reproduction of laboratory records, new processes, etc.—American Instrument Co., Inc., 8030-50 Georgia Ave., Silver Spring, Md.

T-631 **Hermetically Sealed Relays.** 33-page Sales Engineering Bulletin No. 114 illustrates and describes the history of development of sealed relays, and specifications for 40 series of relays.—C. P. Clare & Co., 4719 W. Sunnyside Ave., Chicago 30, Ill.

T-632 **Small Relays.** 3-page Sales Engineering Bulletin No. 115 illustrates and describes maker's line of "Type R" small d-c. operated relays.—C. P. Clare & Co., 4719 W. Sunnyside Ave., Chicago 30, Ill.

T-633 **Relays.** 15-page Catalog 51-3 illustrates and describes maker's line of a-c. and d-c. relays. Includes classification and applications.—Sigma Instruments, Inc., 170 Pearl St., South Braintree, Boston 85, Mass.

T-634 **Permanent Magnets.** 20-page Bulletin No. 151 illustrates and describes fundamental properties of magnets, design, tests, magnet steels, and alnico grades.—Thomas & Skinner

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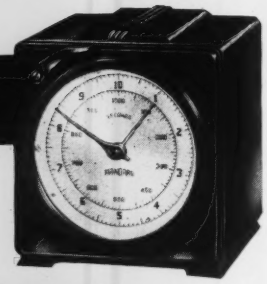

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NEW LITERATURE

Steel Products Co., 1120 East 23rd St., Indianapolis, Ind.

T-635 **Electromagnet.** 3-page reprint of article "A New Type of Electromagnet" illustrates and describes iron-core magnet for laboratory use.—Arthur D. Little, Inc., 30 Memorial Drive, Cambridge 42, Mass.

T-636 **Design of Small Motors.** 4-page Vol. 31 No. 4 issue of house organ "Motorgram" features article "Designing Small Motors for Quiet Operation."—Bodine Electric Co., 2250 W. Ohio St., Chicago 12, Ill.

Valves, Piping, Tubing

T-637 **Valves.** 20-page General Catalog 1500B illustrates and describes maker's line of "Domotor," solenoid-operated, and handwheel valves. Includes construction of seats, plugs, and packing.—The Annin Co., 3500 Union Pacific Ave., Los Angeles 23, Calif.

T-638 **Pressure-reducing Valves.** 4-page Bulletin A.I.A. File No. 30-C-2 illustrates and describes maker's "Series 700" self-operated mechanical-loaded rubber-diaphragm valves, and "Series 710" self-operating rubber-diaphragm-motor valves.—Hoffman Specialty Co., 1001 York St., Indianapolis 7, Ind.

T-639 **Diaphragm Control Valve.** 2-page data sheet for addition to maker's catalog illustrates and describes "Type 886-D" and "Type 886-DRT" diaphragm control valves.—Climax Controls Div., Black, Sivalls & Bryson, Inc., Tulsa 1, Oklahoma.

T-640 **Rubber Tubing.** 20-page issue No. 51-3-42 of house organ "Eberbach Announcer" features article on manufacture of rubber tubing and descriptions of pipettes, electroanalysis apparatus, etc.—Eberbach and Son Co., Ann Arbor, Mich.

T-641 **Instrument Tubing.** 2-page bulletin illustrates and describes maker's "Dekoron" metal tubing covered with plastic armor.—Samuel Moore & Co., Dekoron Tubing Div., Mantua, Ohio.

T-642 **Tube and Pipe Fittings.** Brochure contains three catalogs: 20-page Catalog H-1451-A describes line of reusable steel hose ends and industrial hose; 29-page catalog F-1456 describes line of industrial tube and pipe fittings; 24-page catalog E-1457 describes line of steel and stainless-steel fittings.—Industrial Sales Div., The Weatherhead Co., 300 E. 131 St., Cleveland 8, Ohio.

Vibration

T-643 **Vibration Fatigue Testers.** 6-page folder describes and illustrates line of fatigue testers which vibrate either vertically or horizontally.—All American Tool & Mfg. Co., 1014 Fullerton Ave., Chicago 14, Ill.

T-644 **Shock Resistance.** 16-page bulletin "Designing for Shock Resistance" illustrates and describes basic concepts of design, including weight, energy storage, stress concentration, etc.—The Barry Corporation, 720 Pleasant St., Watertown 72, Mass.

T-645 **Shock Mounts.** 4-page Bulletin 607 illustrates and describes maker's "Barrymounts". Includes reasons

for use and how to select mounts.—The Barry Corporation, 700 Pleasant St., Watertown 72, Mass.

T-646 **Packaging.** 8-page booklet titled "Package Cushioning" describes properties of cushioning materials. Includes table of properties and summary of sponge-rubber products.—The Sponge Rubber Products Co., Shelton, Conn.

Instrument Shop Equipment

T-647 **Plastic Utility Boxes.** 4-page bulletin describes transparent plastic utility boxes for small parts.—Bradley Industries, 1650-52 North Damen Ave., Chicago 47, Ill.

T-648 **Pivot Cleaner.** 1-page Bulletin No. 501 describes maker's treated buttonwood pith for cleaning and lubricating pivots and shafts.—Welton V. Johnson Engineering Co., Inc., 95 Summit Ave., Summit, N. J.

T-649 **Soldering Paste.** 1-page Bulletin No. 401 describes maker's instrument soldering paste for hair springs and small instrument parts.—Welton V. Johnson Engineering Co., Inc., 95 Summit Ave., Summit, N. J.

T-650 **Mercury Cleaners.** 4-page brochure describes maker's laboratory and industrial oxifiers and filters for cleaning mercury—Bethlehem Apparatus Co., Front and Depot Sts., Hellertown, Penna.

T-651 **Machine Tolerance.** 4-page folder titled "Just What Tolerances Can That Machine Meet" describes statistical quality-control technique for determining machine tolerance. Cost 10c.—V. W. Palen, Bureau of Public Information, New York University College of Engineering, New York 53, N. Y.

T-652 **Instrument Making.** Vol. 2 No. 9 issue of house organ "hp Journal" describes manufacturing operations, such as low-cost molding, which decreased costs.—Hewlett-Packard Co., 395 Page Mill Road, Palo Alto, Calif.

T-653 **Electroplating Rectifier.** 1-page bulletin illustrates and describes convection-cooled "RA" 150-amp. electroplating rectifier.—Electronic Rectifier Co., Inc., Rochester 2, N. Y.

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T-654 **Dividing Head.** 12-page Catalog 10 illustrates and describes maker's "OPL" dividing head, which uses optical means for positioning.—F. T. Griswold Mfg. Co., Wayne, Penna.

T-655 **Slope-control for Welding.** 4-page No. 15 issue of house organ "Technical Advisor" features article on new slope-control of a-c. spotwelding

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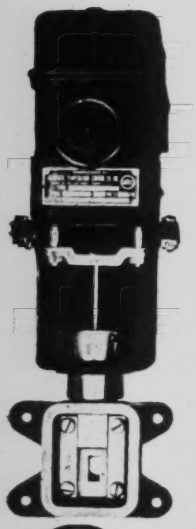

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This Rockwell Valve can be equipped with electric motor (left), air diaphragm operator (right), with valve positioner, if desired; hydraulic cylinder, solenoid or other controls; or it may be manually operated.

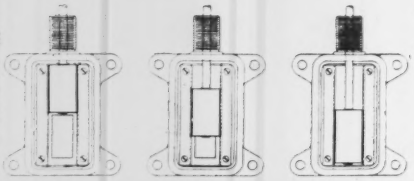
SIMPLE DESIGN

Removal of valve cover exposes stainless steel internal parts for easy maintenance. The slide or blade and body are lapped to provide smooth, tight closure. No wire drawing, wear on valve seats, mislocation of contacting parts. Sizes—¼" to 2"; pressures to 300 p.s.i.

FREE FLOW

As shown in sketches, vertical movement of blade over the rectangular opening determines open area. Flow is straight through, without seats or bends with their restriction to flow and consequent pressure drop. Flow is directly proportional to the degree of opening.

Write for Bulletin



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NEW LITERATURE

for aluminum, and on machining aluminum.—Reynolds Metals Co., 2500 So. Third St., Louisville, 1, Ky.

T-656 **Vapor Degreasing.** 21-page handbook on vapor degreasing of metal parts answers questions on the subject. Includes equipment and tables on solvents.—Phillips Manufacturing Co., 3475 Touhy Ave., Chicago, Ill.

T-657 **Coolant System.** 1-page bulletin describes new coolant system for machine tools. Includes description of components—all-rubber pump, motor, 4-gallon container, and flow-control valve.—Samuel S. Gelber Co., 162 N. Clinton St., Chicago 6, Ill.

T-658 **Drill Press.** 2-page bulletin illustrates and describes maker's "Micro" drill press for drilling holes as small as 0.002 in.—Louis Levin & Son, Inc., 782 E. Pico Blvd., Los Angeles 21, Calif.

T-659 **Plastics.** 8-page Vol. 18 No. 5 issue of house organ "Plastic News" features articles on use of plastics in sprayer, pressure gage, instrument, etc. —Durez Plastics & Chemicals, Inc., North Tonawanda, N. Y.

T-660 **Industrial Counters.** 4-page Bulletin SK-22 illustrates and describes maker's line of "Silver King" mechanical counters.—Production Instrument Co., 702 W. Jackson Blvd., Chicago 6, Ill.

T-661 **Production Control.** 20-page Vol. X No. 7 issue of house organ "The Martin Star" features article on cycle plan for production control of sub-assembly jobs, structural tests on airliners, etc.—The Glenn L. Martin Co., Baltimore 3, Md.

T-662 **Plant Protection.** 16-page booklet "Plant Protection for National Defense" is manual of regulations and instructions for watchmen, guards, and management. Includes description of maker's watchclock.—Detex Watchclock Corp., 76 Varick St., New York 13, N. Y.

T-663 **Engineering Data.** 1-page sheet describes maker's "CARD-ALL" spiral-bound cards which list engineering data such as natural function of angles, decimal equivalents, etc.—General Design Co., 1200 Commercial Trust Building, Philadelphia 2, Penna.

T-664 **Aircraft Test Equipment.** 8-page catalog describes maker's hydraulic-component and pump test-stand, fuel-pump test-stand, and other equipment.—Sprague Engineering and Sales Co., 1144 W. 135th St., Gardena, Calif.

T-665 **Electronics Facilities Brochure.** 8-page brochure, Form SA7-651, illustrates and describes organization, facilities, and products of electronics design, and manufacturing concern.—Sierra Electronic Corp., San Carlos, Calif.

T-666 **Aircraft and Marine Products.** 40-page booklet lists products of maker's 15 plants and describes manufacturing facilities.—Bendix Aviation Corp., Fisher Bldg., Detroit 2, Mich.

T-667 **Synchronous-motors and Instruments.** 20-page brochure illustrates and describes products, engineering staff, and manufacturing facilities of company.—Telechron, Inc., Ashland, Mass.

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SPECIFICATIONS

–hp– 460B FAST PULSE AMPLIFIER

FREQUENCY RESPONSE: Closely matches Gaussian curve. Hf 3 db point is approx. 140 mc. Lf 3 db point is approx. 50 kc into 200-ohm load.
MAXIMUM OUTPUT VOLTAGE: High bias, approx. 125 v. negative open circuit. Normal bias (linear amplification) approx. 8 v. peak into 200-ohm load or 16 v. peak open circuit, pos. or neg. pulses.
GAIN: Approx. 15 db into 200-ohm load.
INPUT IMPEDANCE: Approx. 200 ohms.
RISE TIME: Approx. 0.0026 μsec.
DELAY: Approx. 0.016 μsec.
DUTY CYCLE: 0.10 max. for 125 v. output pulse.
LINEARITY PULSE OPERATION: See Figure 1.
MOUNTING: Relay rack. 5¼" x 19". 6" deep.
POWER SUPPLY: 115 v. 50/60 cps. 35 watts.
PRICE: $225.00 f.o.b. factory.

–hp– 460A WIDE-BAND AMPLIFIER

(Specifications same as Model 460B except:)
MAXIMUM OUTPUT VOLTAGE: Approx. 8 v. peak open circuit; 4.75 v. peak into 200-ohm load.
GAIN: Approx. 20 db with 200-ohm load.
DELAY: Approx. 0.012 μsec.
PRICE: $185.00 f.o.b. factory.

–hp– 46A ACCESSORIES

–hp– 46A-16A PATCH CORD – 200-ohms, 2' long. $18.50.
–hp– 46A-16B PATCH CORD – 200-ohms, 6' long. $25.50.
–hp– 46A-95A PANEL JACK—For 200-ohm cables, low capacitance. 1⅛" dia. $7.50.
–hp– 46A-95B CABLE PLUG—For 200-ohm cables, low capacitance. $7.50.
–hp– 812-52 CABLE—200-ohm cable in lengths to specification. Per foot $1.75.
–hp– 46A-95C 50-OHM ADAPTOR – Type N connector for coupling 50-ohm line into –hp– amplifiers. $15.00.
–hp– 46A-95D ADAPTOR—Bayonet sleeve for connecting –hp– 410A VTVM to output of 460A/B amplifiers. $15.00.
–hp– 46A-95E CONNECTOR SLEEVE—Joins two 46A-95B CABLE PLUGS. $7.50.
–hp– 46A-95F ADAPTOR—For connecting to 5XP CRT. $10.00.
–hp– 46A-95G ADAPTOR—For connecting to Tektronix type 511 oscilloscope. $12.50.

Data subject to change without notice.

UP TO 90 DB GAIN IN CASCADE! AMPLIFIES MILLI-MICROSECOND PULSES! RISE TIME .0026 μSEC! 125-VOLT OPEN-CIRCUIT OUTPUT! GIVES OVER 100 MC BANDWIDTH TO YOUR STANDARD OSCILLOSCOPE!

Here at last is complete instrumentation for true amplification of fast pulses at high power levels sufficient to operate scalers or counting meters, cathode ray tubes, or to give more than 100 mc band-width to your present oscilloscope. New –*hp*– 460B Fast-Pulse Amplifiers, in cascade with –*hp*– 460A Wide-Band Amplifiers, amplify up to 125 volts, open circuit (limited duty cycle). This permits full deflection of 5XP cathode ray tubes, or 2-inch deflection of 5CP tubes. Ultra-short rise time of 0.0026 μsec, combined with zero overshoot, insures distortion-free amplification of pulses faster than 0.01 μsec.

New –*hp*– 460B Amplifier, cascaded with –*hp*– 460A provides linear amplification of 16 volts peak output and pulse amplification of 125 volts output (slight non-linearity). This combination provides maximum usefulness in fast-pulse study for nuclear radiation work, television or VHF research; for increasing frequency range of your oscilloscope, or general wide-band laboratory amplification. In addition to the above instrumentation, –*hp*– also offers series 46A accessories—a complete set of 200 ohm cables, adapters and fittings for inter-connecting amplifiers or patching to oscilloscopes.

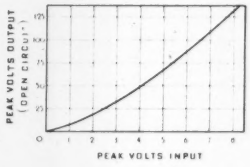

Fig. 1: Linearity of -hp- 460B Fast-Pulse Amplifier

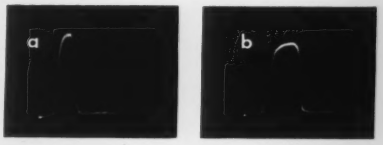

Fig. 2: (a) 0.01 μsec pulse through -hp- 460B Amplifier (b) 0.02 μsec pulse through 3 amplifiers in cascade

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